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Furukawa

(10) **Patent No.: US 8,072,412 B2**
(45) **Date of Patent: Dec. 6, 2011**

(54) **BACKLIGHT, BACKLIGHT DRIVE APPARATUS, DISPLAY APPARATUS**

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(73) Assignee: **Sony Corporation**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1116 days.

(21) Appl. No.: **11/838,574**

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Related U.S. Application Data

(62) Division of application No. 10/511,706, filed as application No. PCT/JP2004/001213 on Feb. 5, 2004, now Pat. No. 7,413,330.

(30) **Foreign Application Priority Data**

Feb. 24, 2003 (JP) 2003-046406

(51) **Int. Cl.**
G09G 3/36 (2006.01)

(52) **U.S. Cl.** **345/102**; 349/70

(58) **Field of Classification Search** 345/102; 349/61–72

See application file for complete search history.

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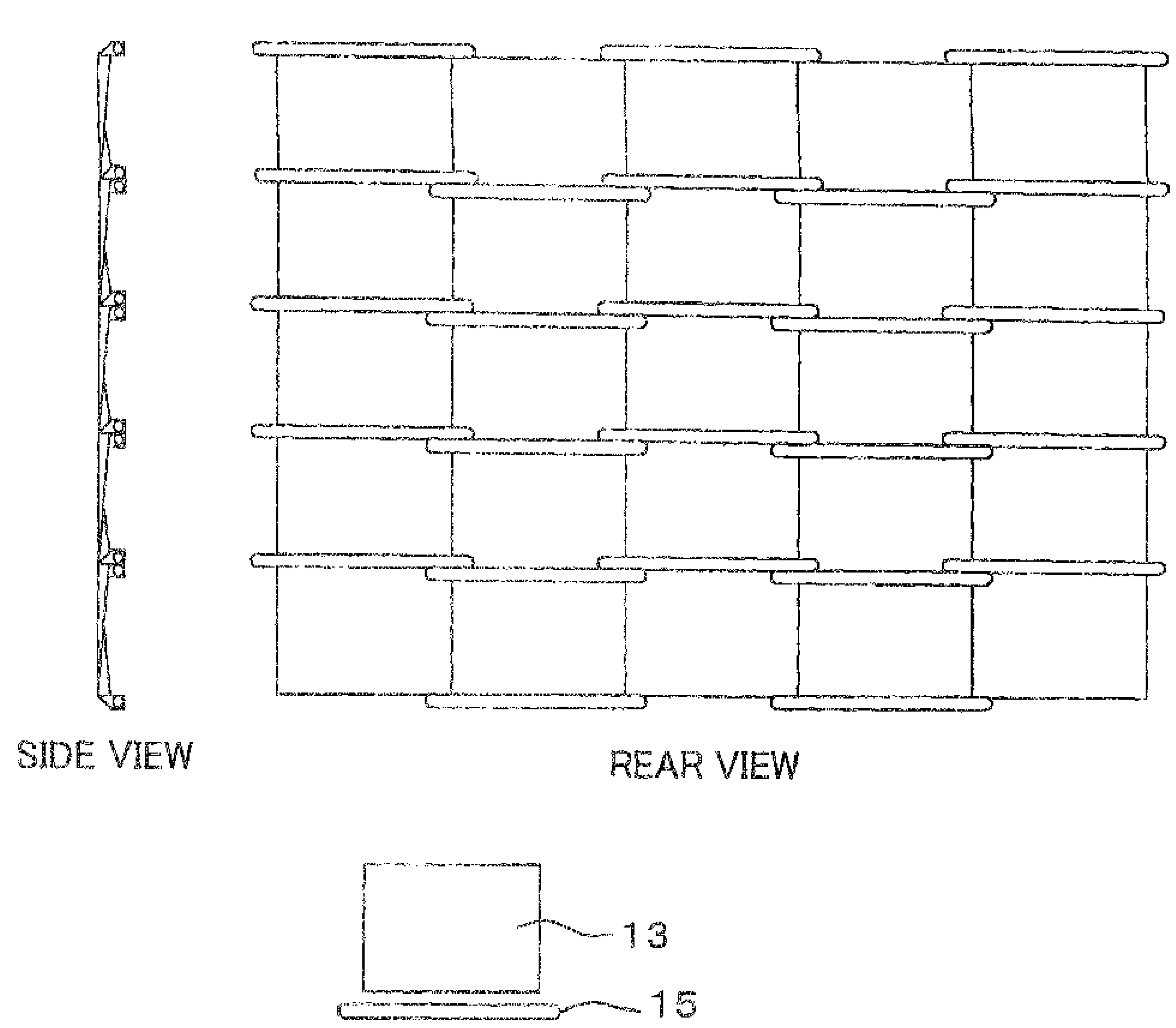
Primary Examiner — Jimmy H Nguyen

(74) *Attorney, Agent, or Firm* — Oblon, Spivak, McClelland, Maier & Neustadt, L.L.P.

(57) **ABSTRACT**

A proposed backlight is suitable for a large size liquid crystal display. A backlight **2** for illuminating a liquid crystal panel **3** from the rear, is formed by combining a plurality of backlight units **10**, **10**, ... By providing a transparent acrylic board **4** between the backlight **2** and the liquid crystal panel **3**, it becomes possible to prevent brightness unevenness from occurring at a junction section of the backlight units **10**, **10**, . . . , even when the backlight is formed by combining the plurality of the backlight units **10**, **10**, ...

9 Claims, 27 Drawing Sheets



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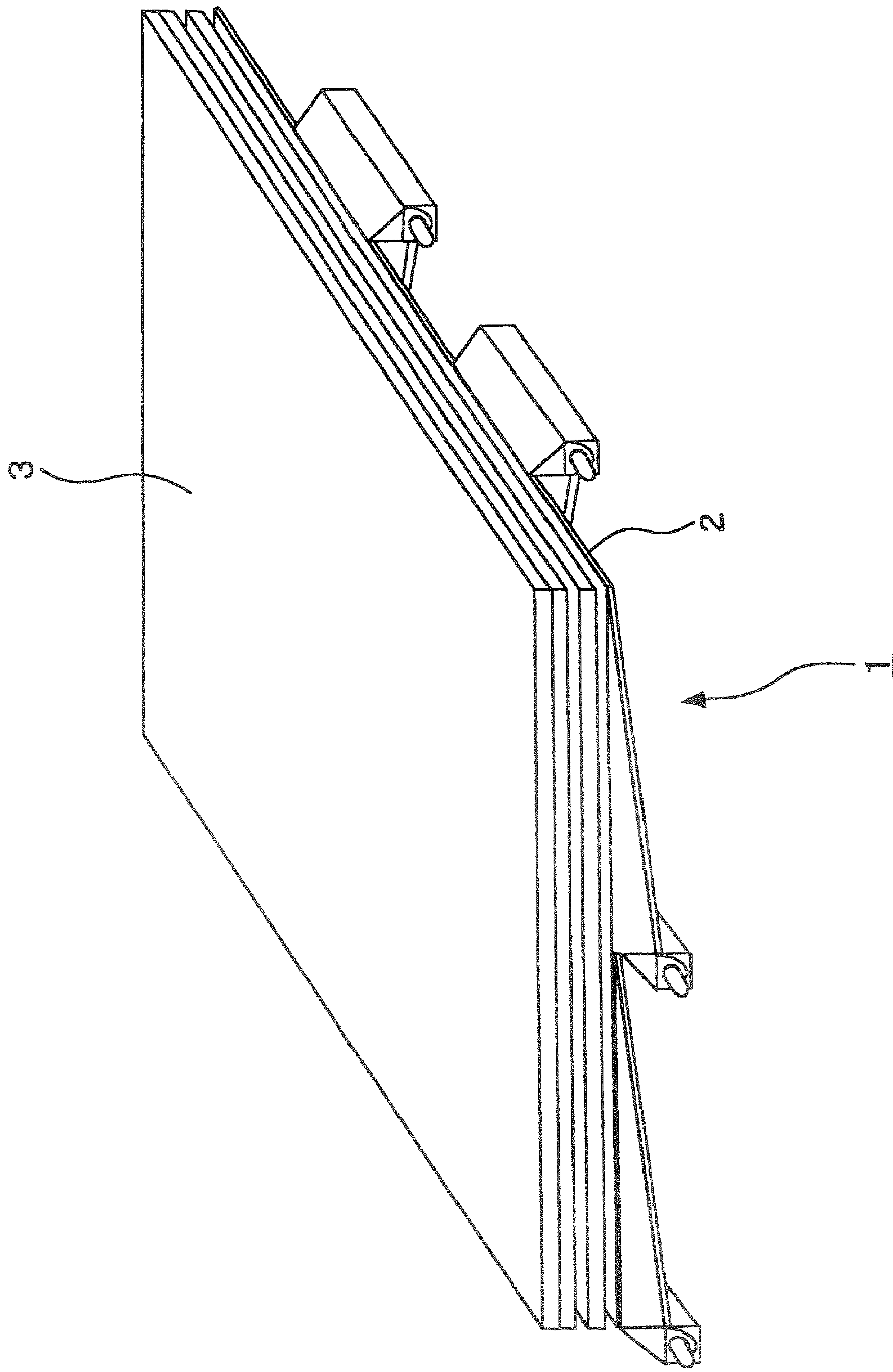


Fig. 1

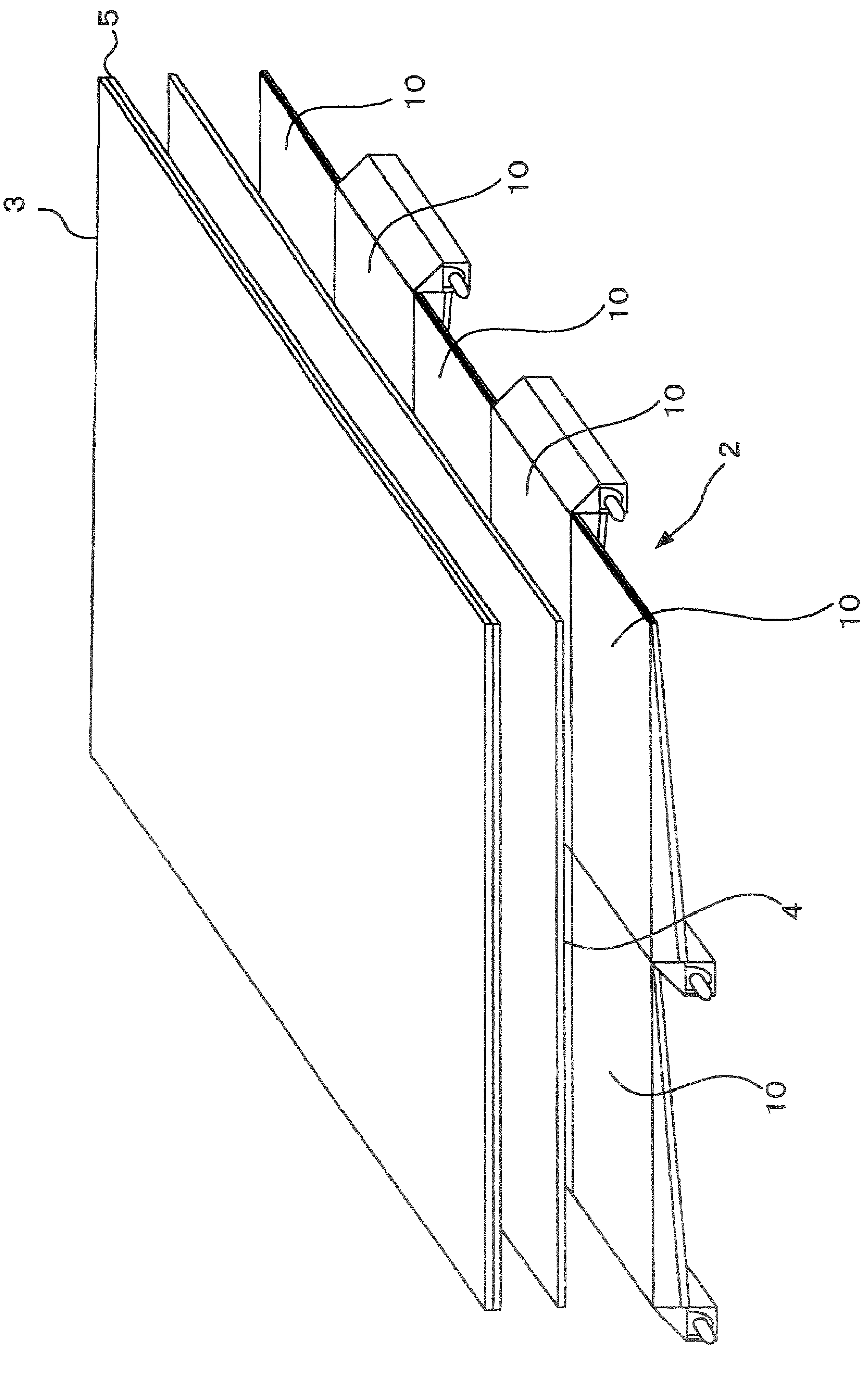


Fig.2

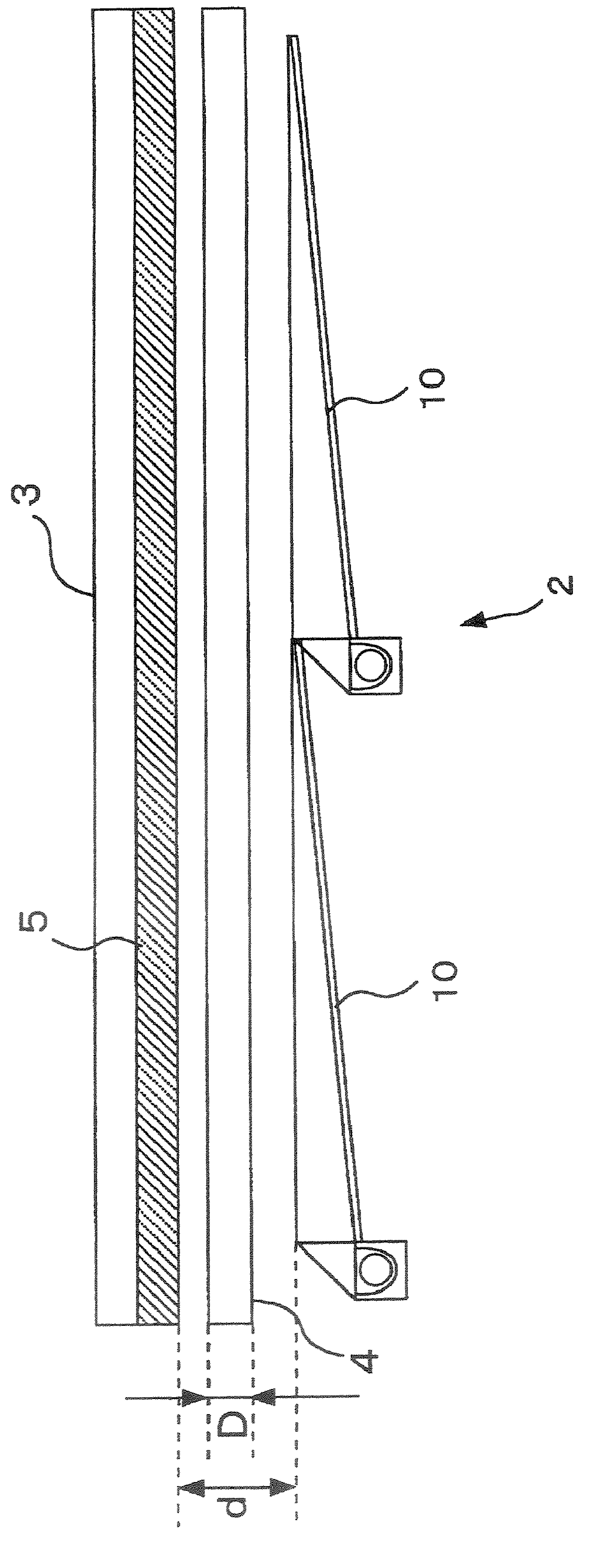


Fig.3

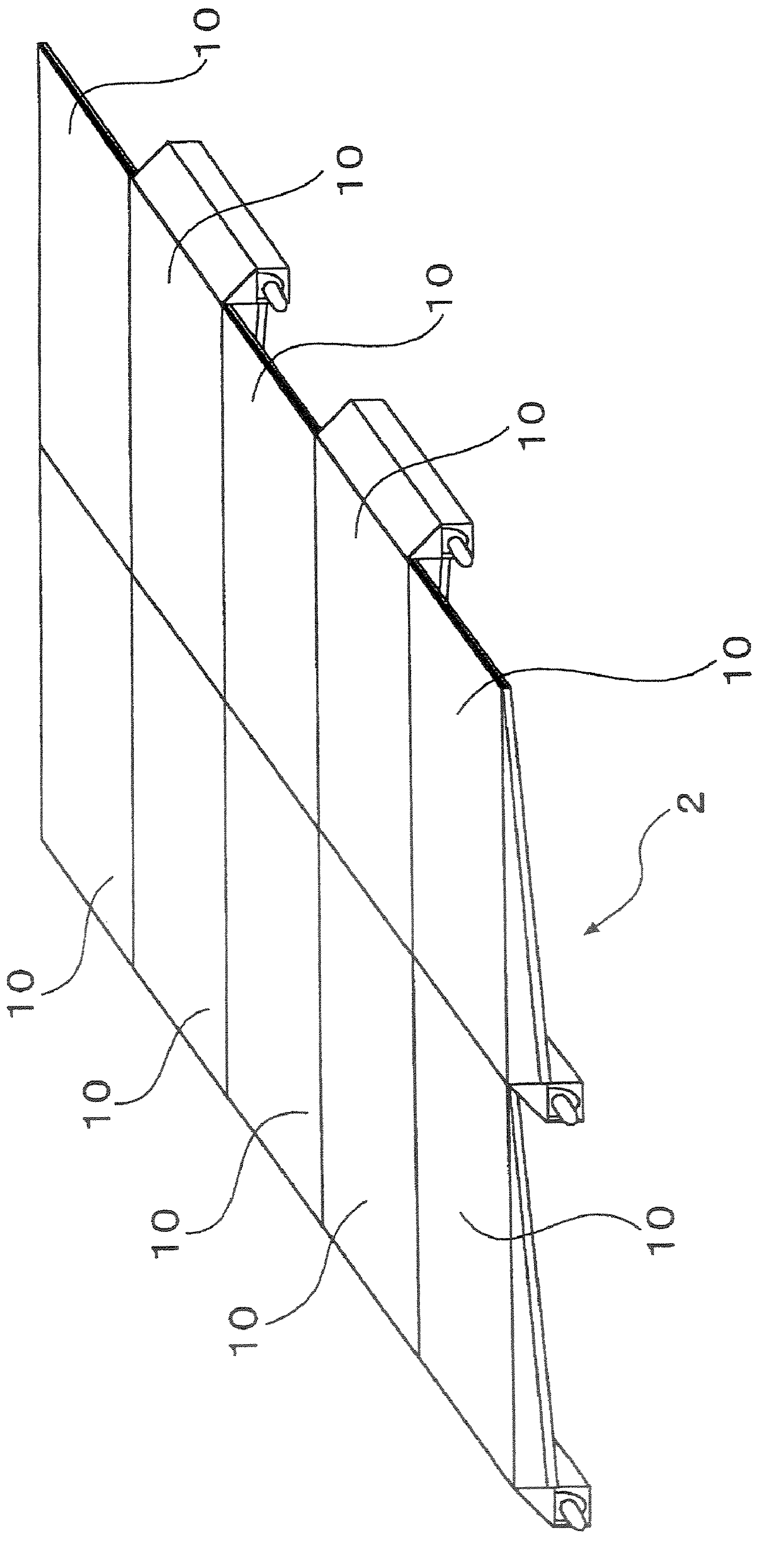


Fig.4

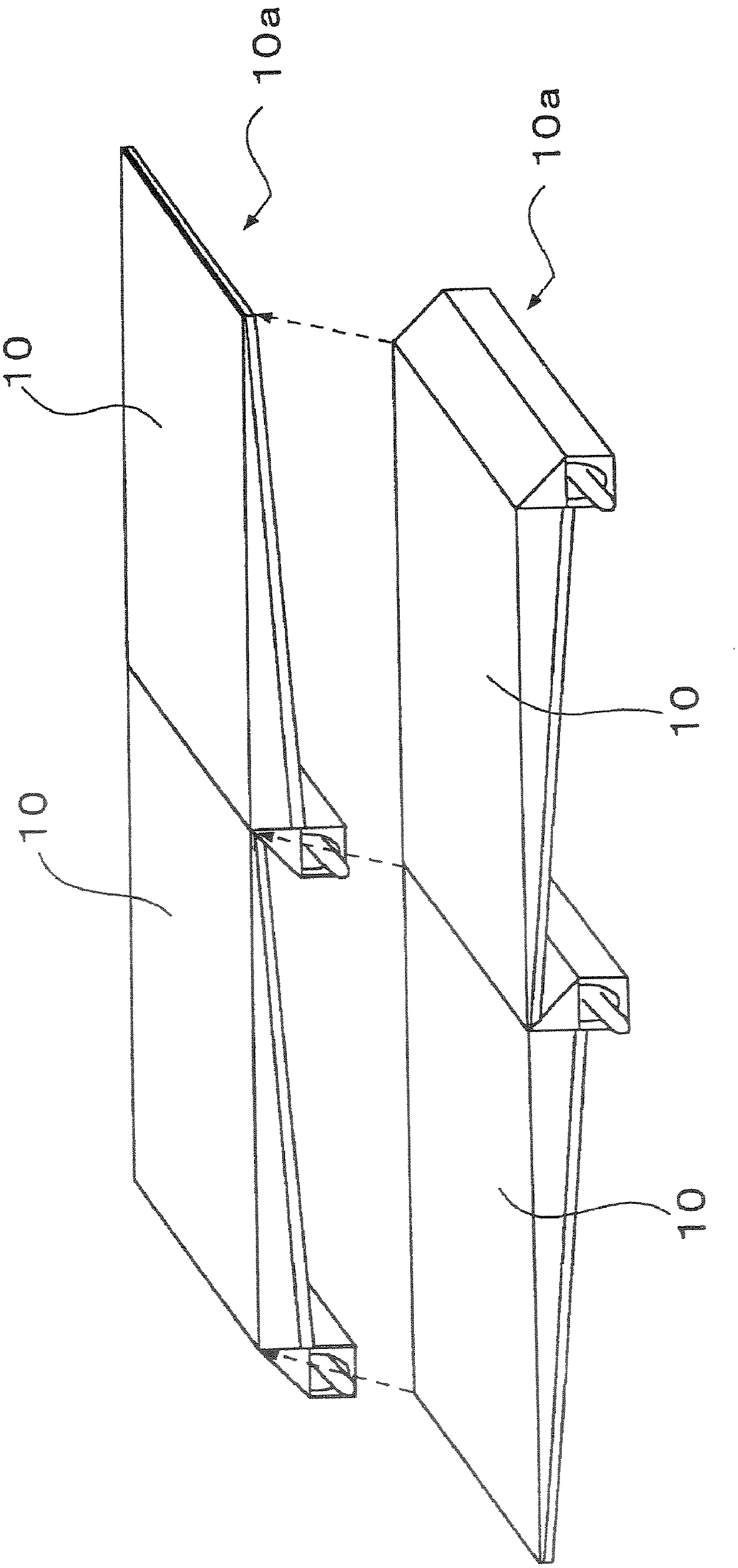


Fig.5

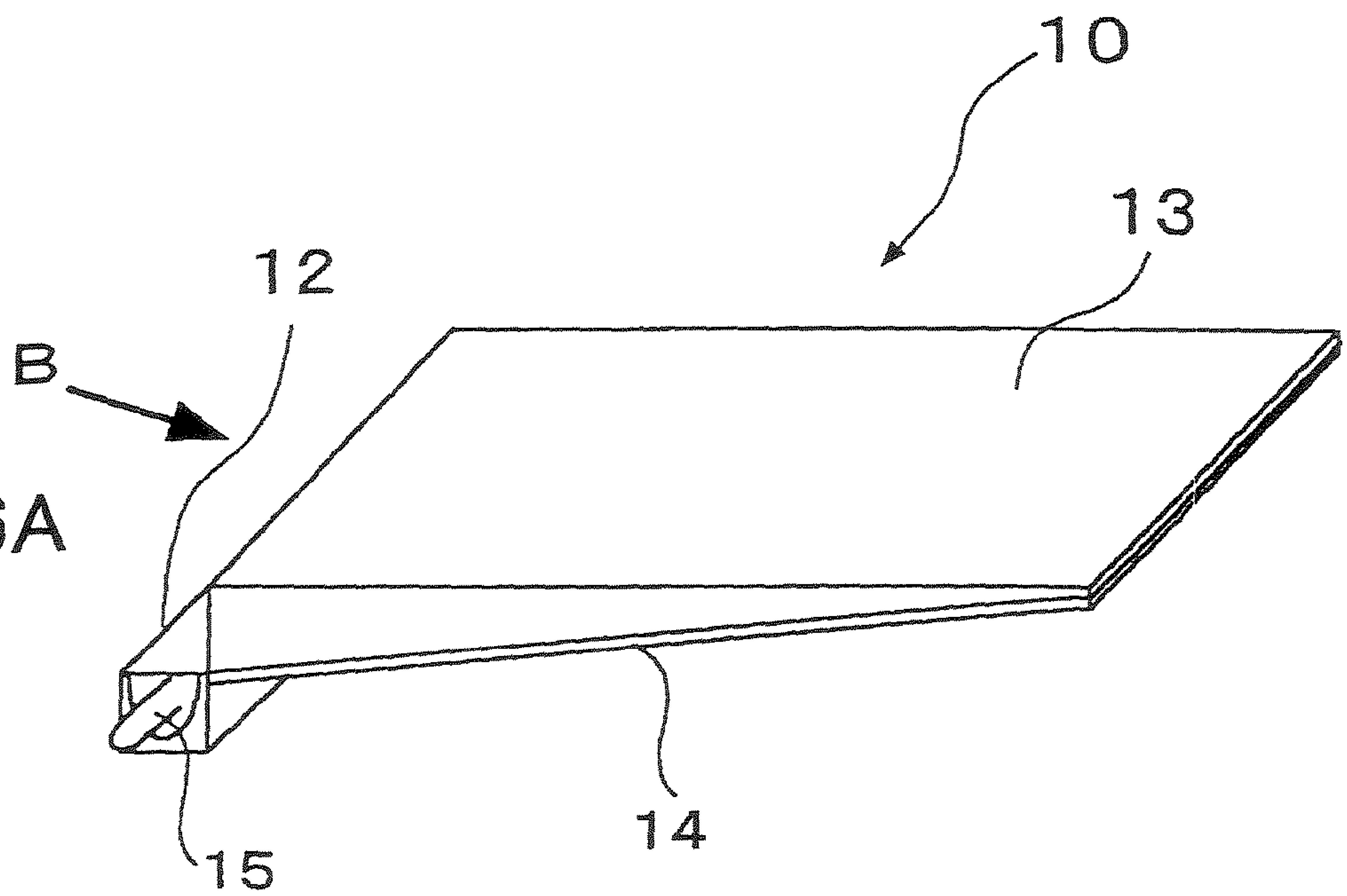


Fig.6A

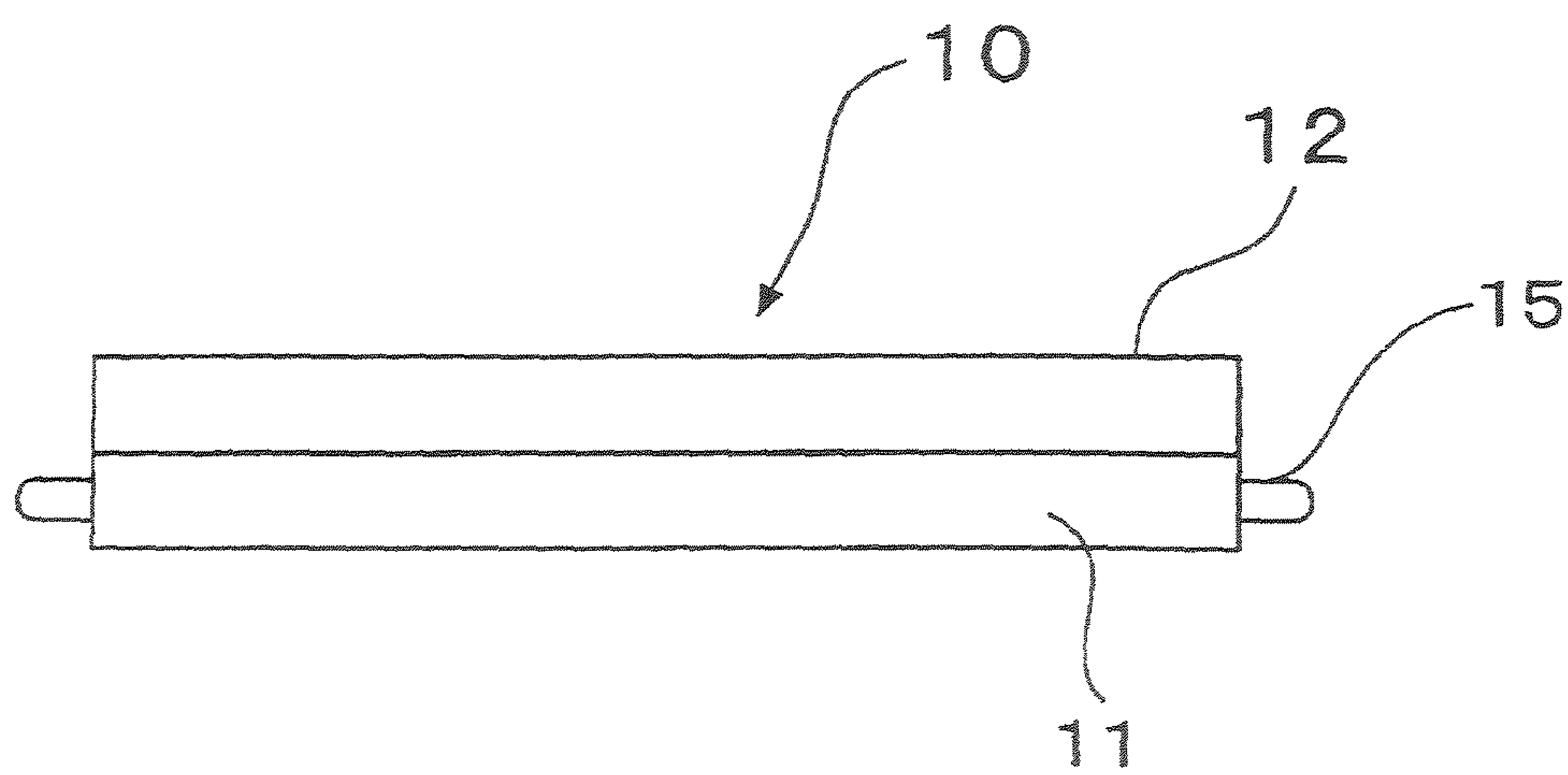


Fig.6B

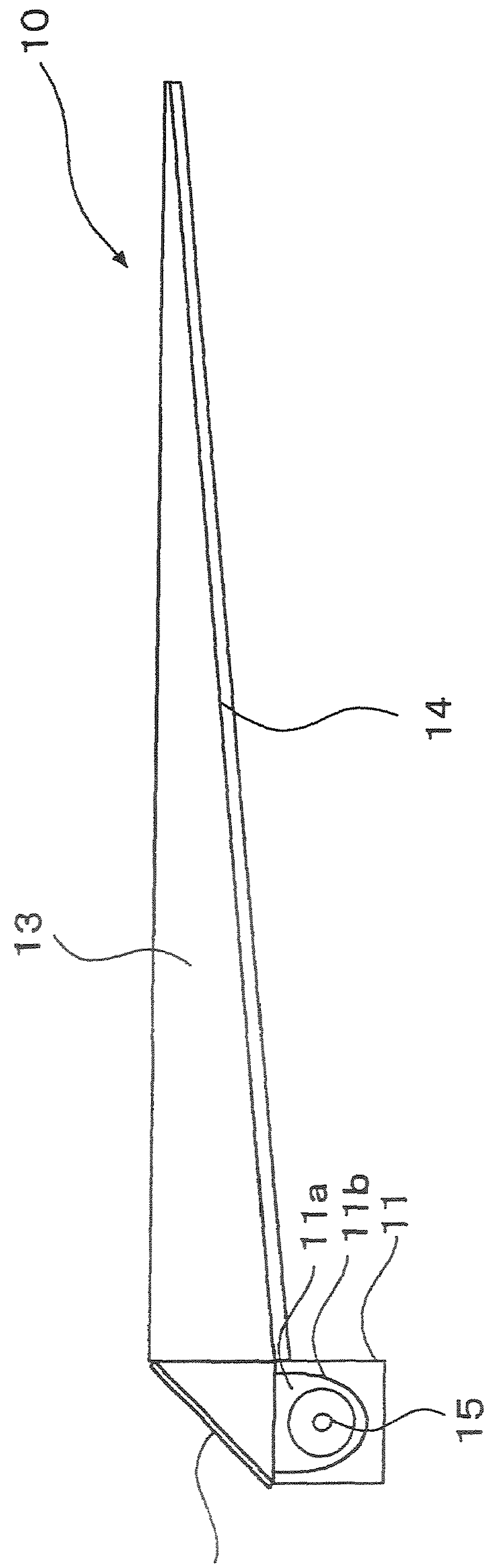


Fig.7A

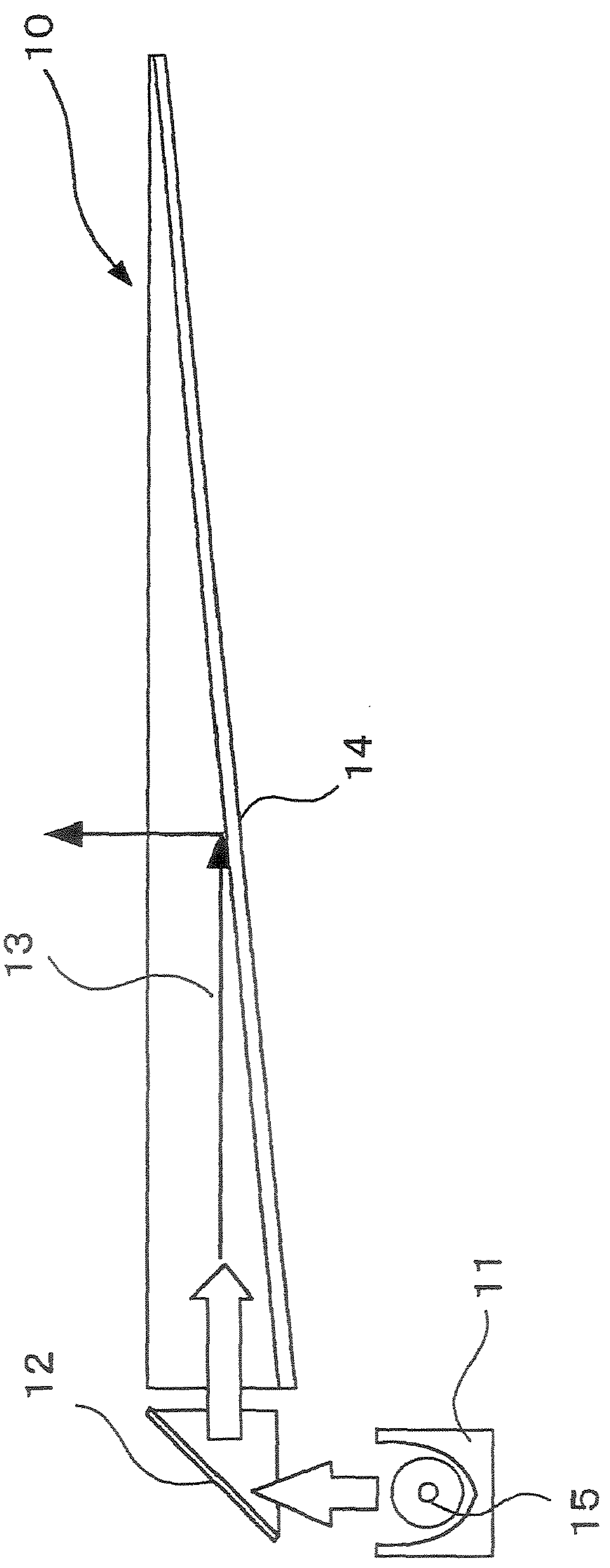


Fig.7B

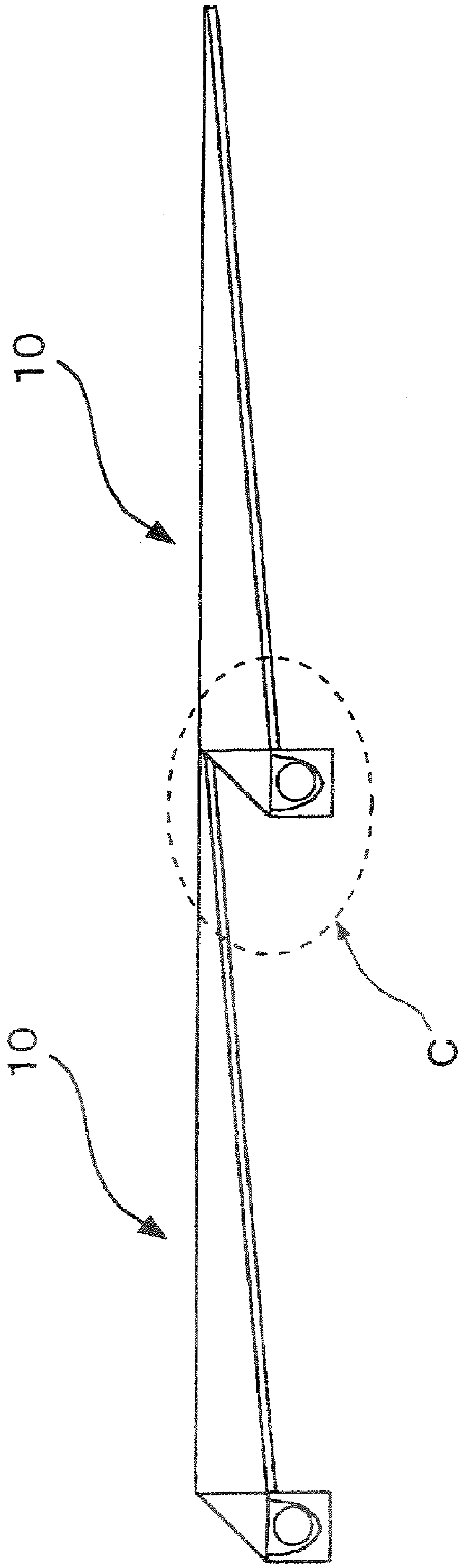


Fig.8A

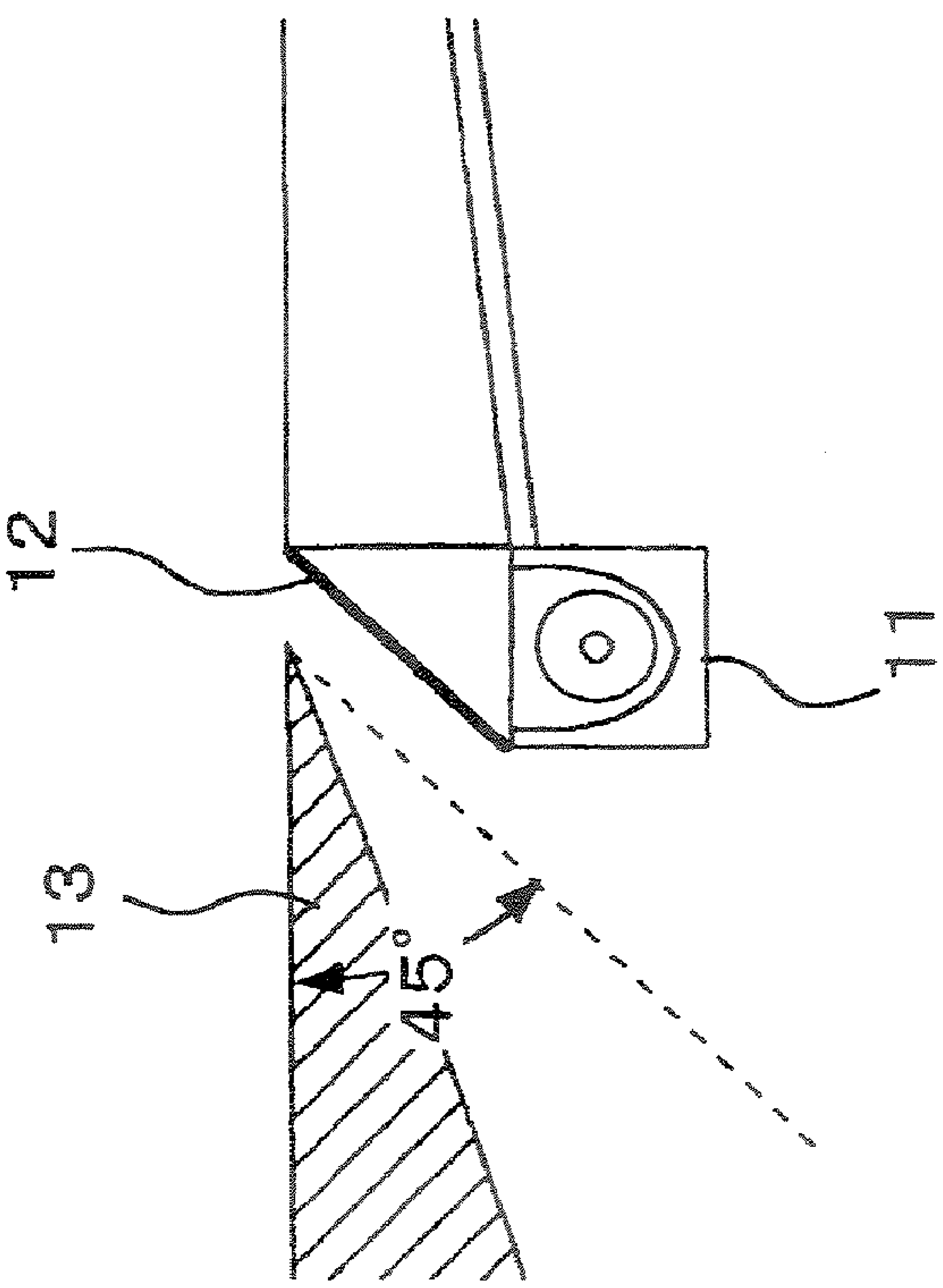


Fig.8B

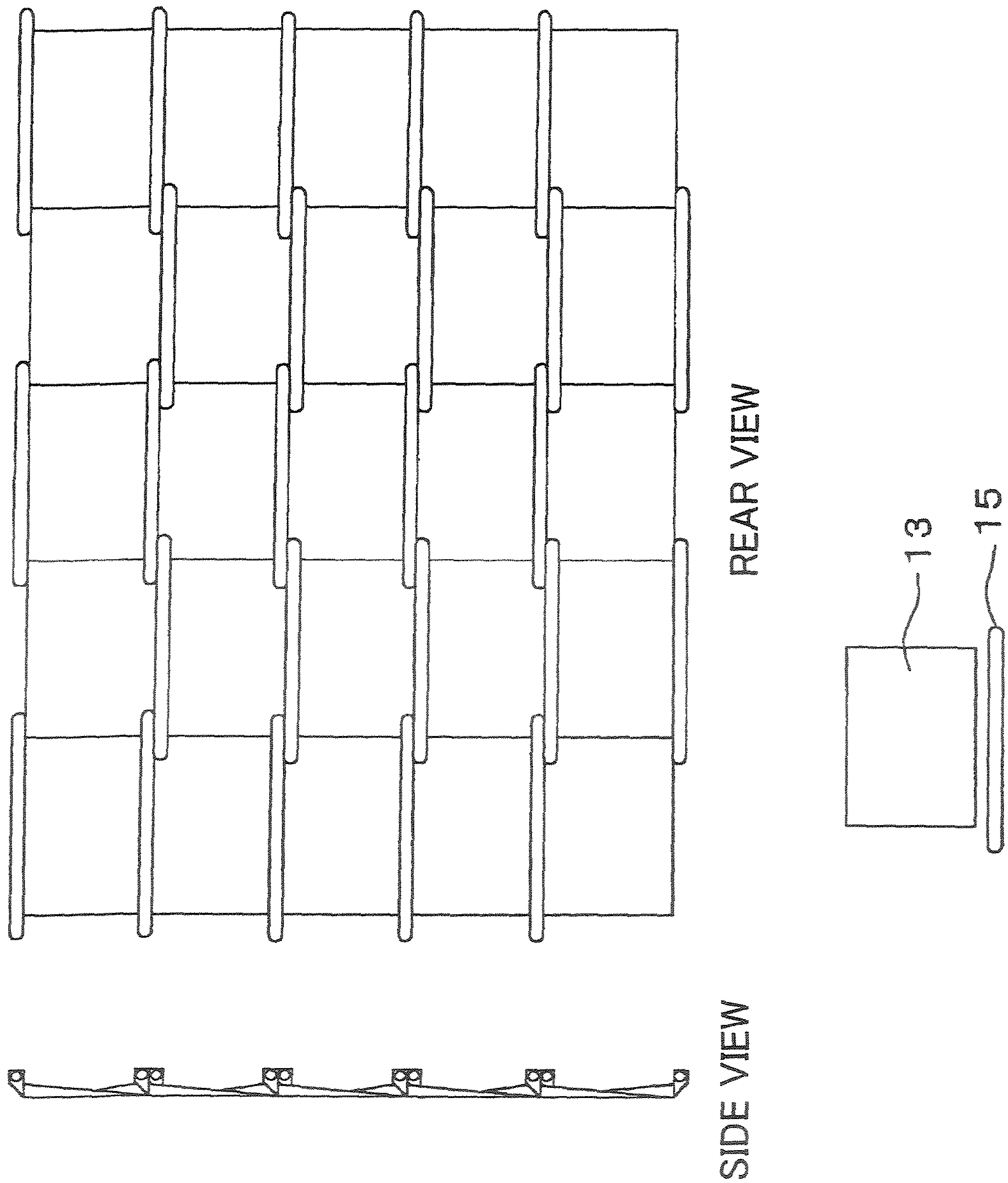
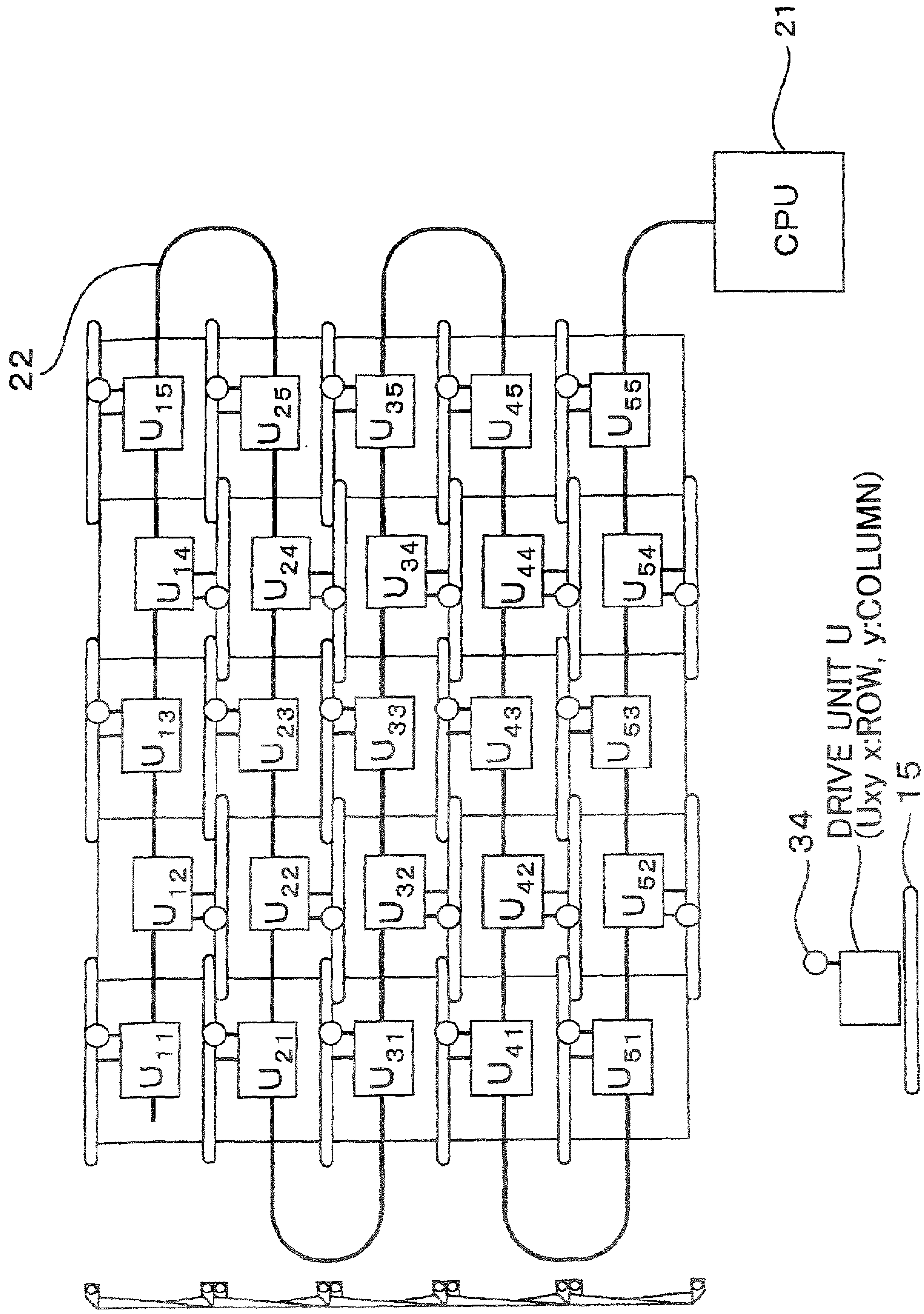


Fig.9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CPU
22
U15
U25
U35
U45
U55
U14
U24
U34
U44
U54
U13
U23
U33
U43
U53
U12
U22
U32
U42
U52
U11
U21
U31
U41
U51
34
DRIVE UNIT U
(Uxy x:ROW, y:COLUMN)
15

Fig.10

FIG.11

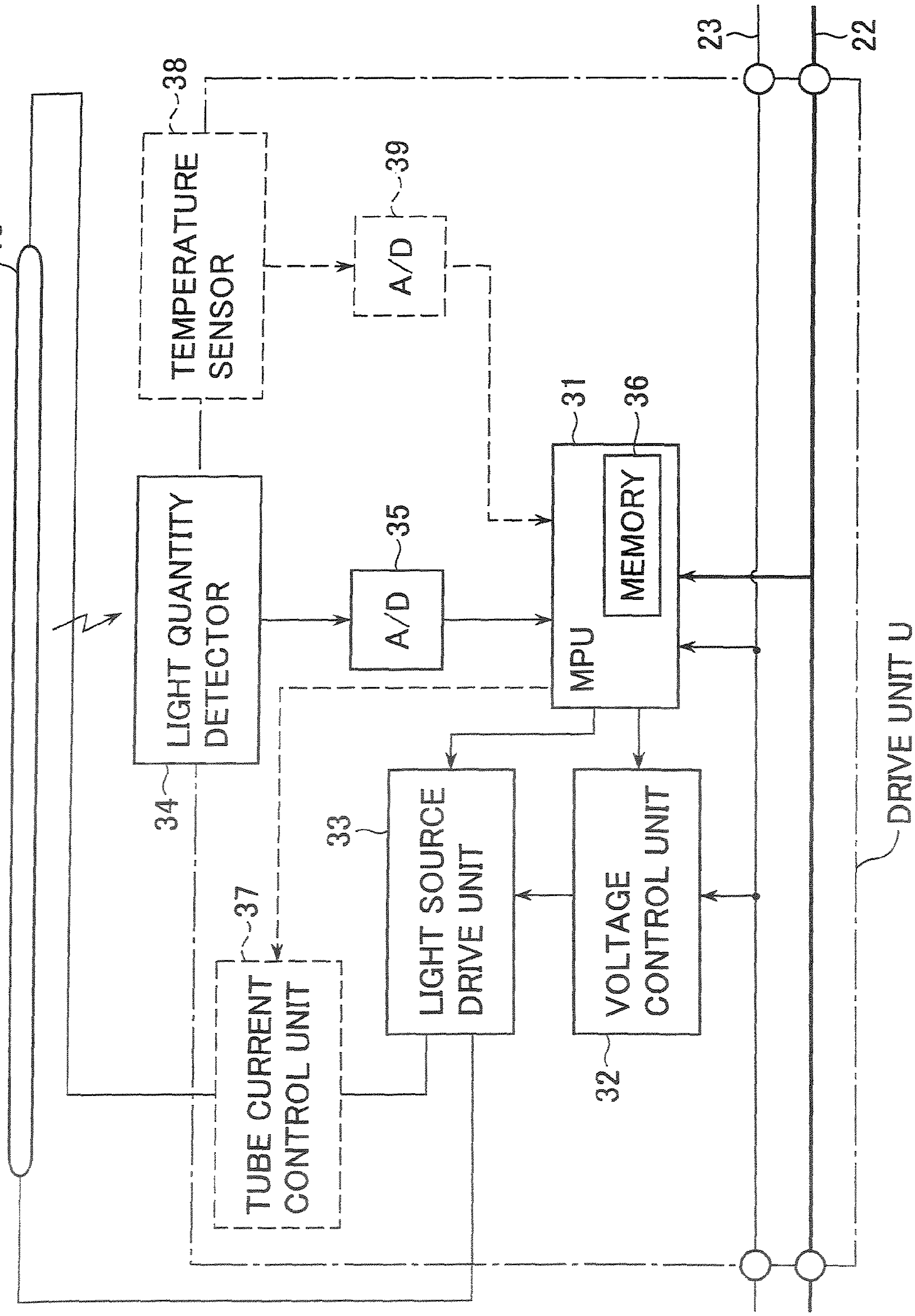

15
TEMPERATURE SENSOR
38
A/D
39
LIGHT QUANTITY DETECTOR
34
A/D
35
MPU
31
MEMORY
36
TUBE CURRENT CONTROL UNIT
37
LIGHT SOURCE DRIVE UNIT
33
VOLTAGE CONTROL UNIT
32
23
22
DRIVE UNIT U

Fig.12A

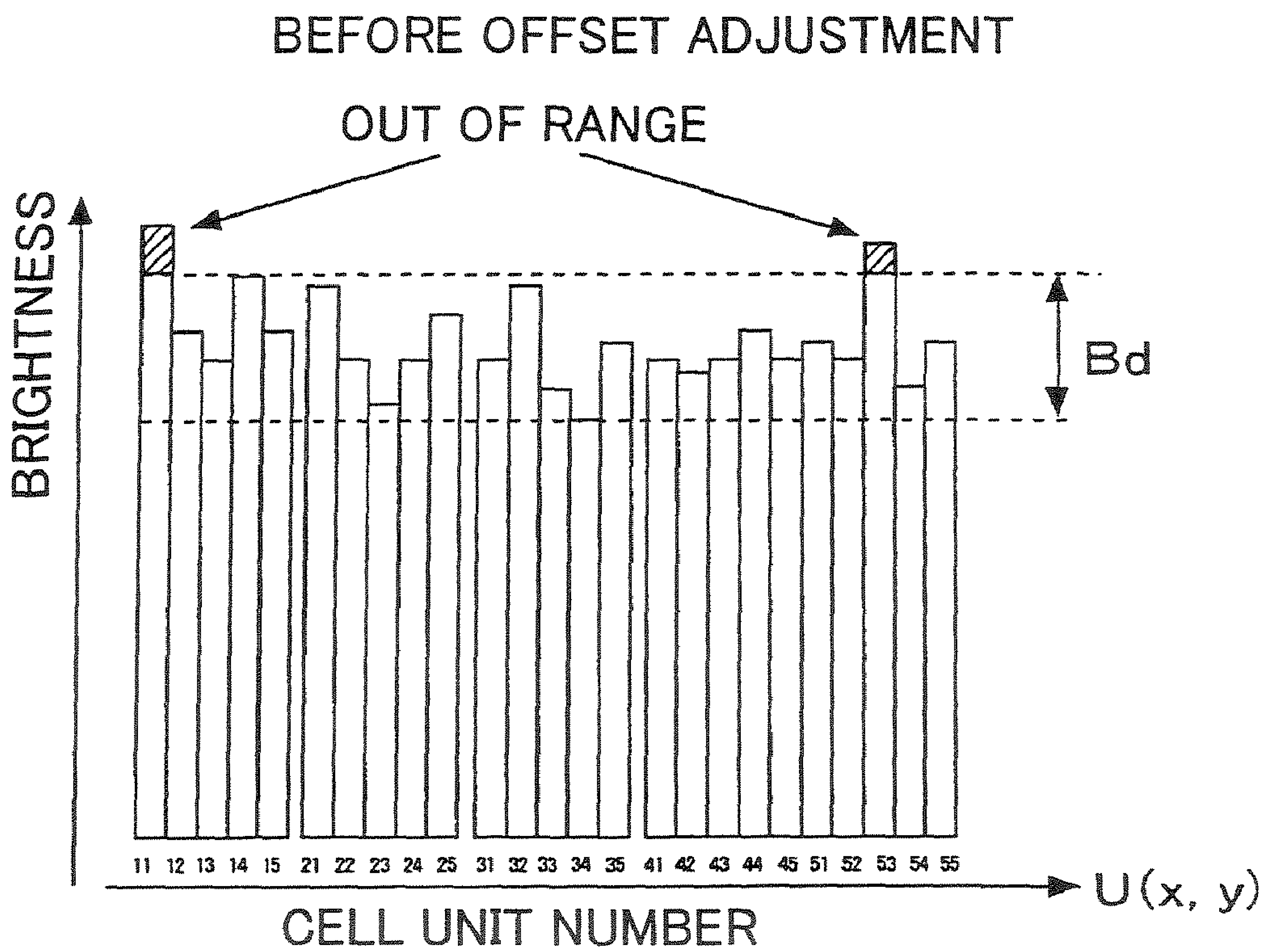
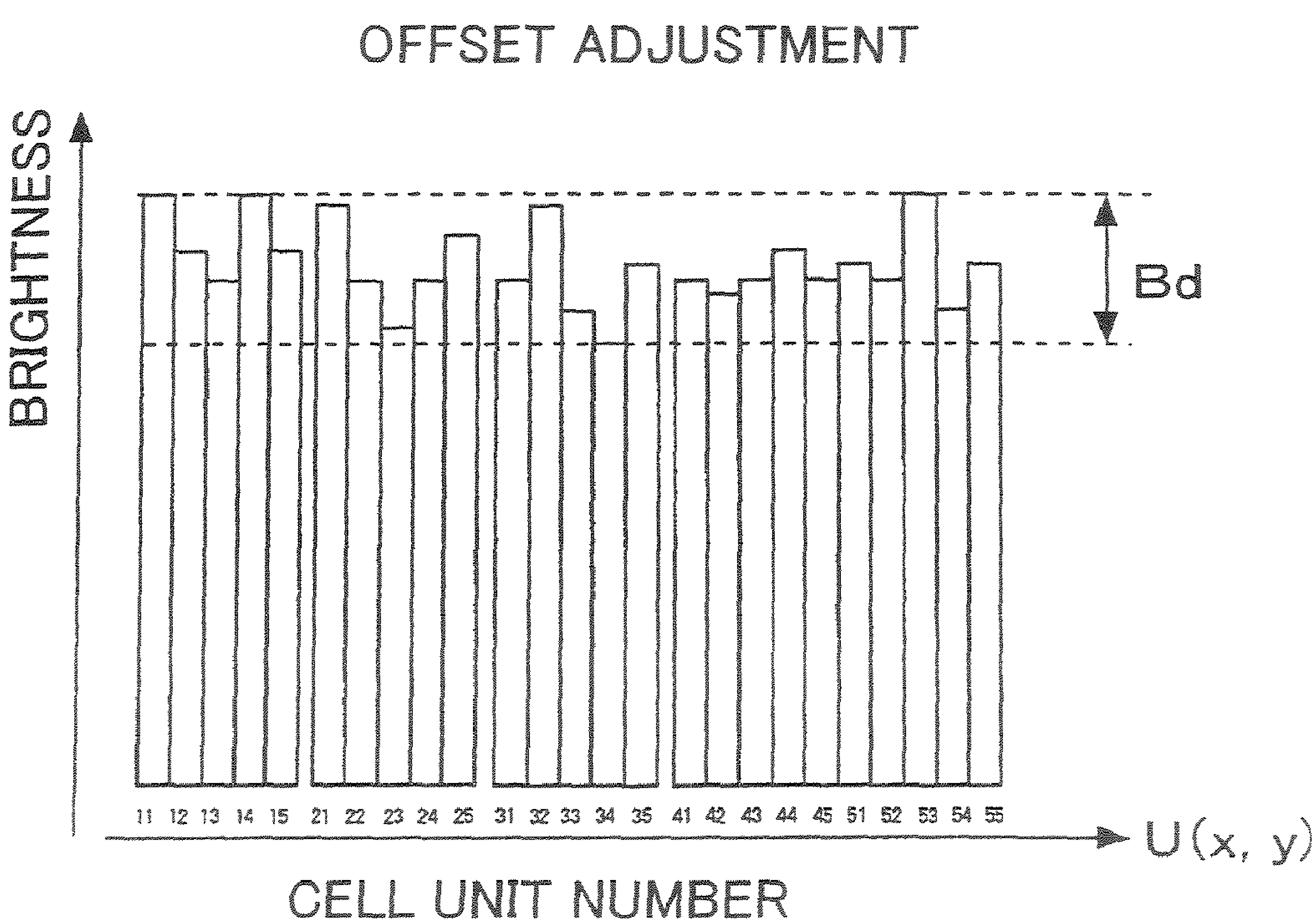


Fig.12B



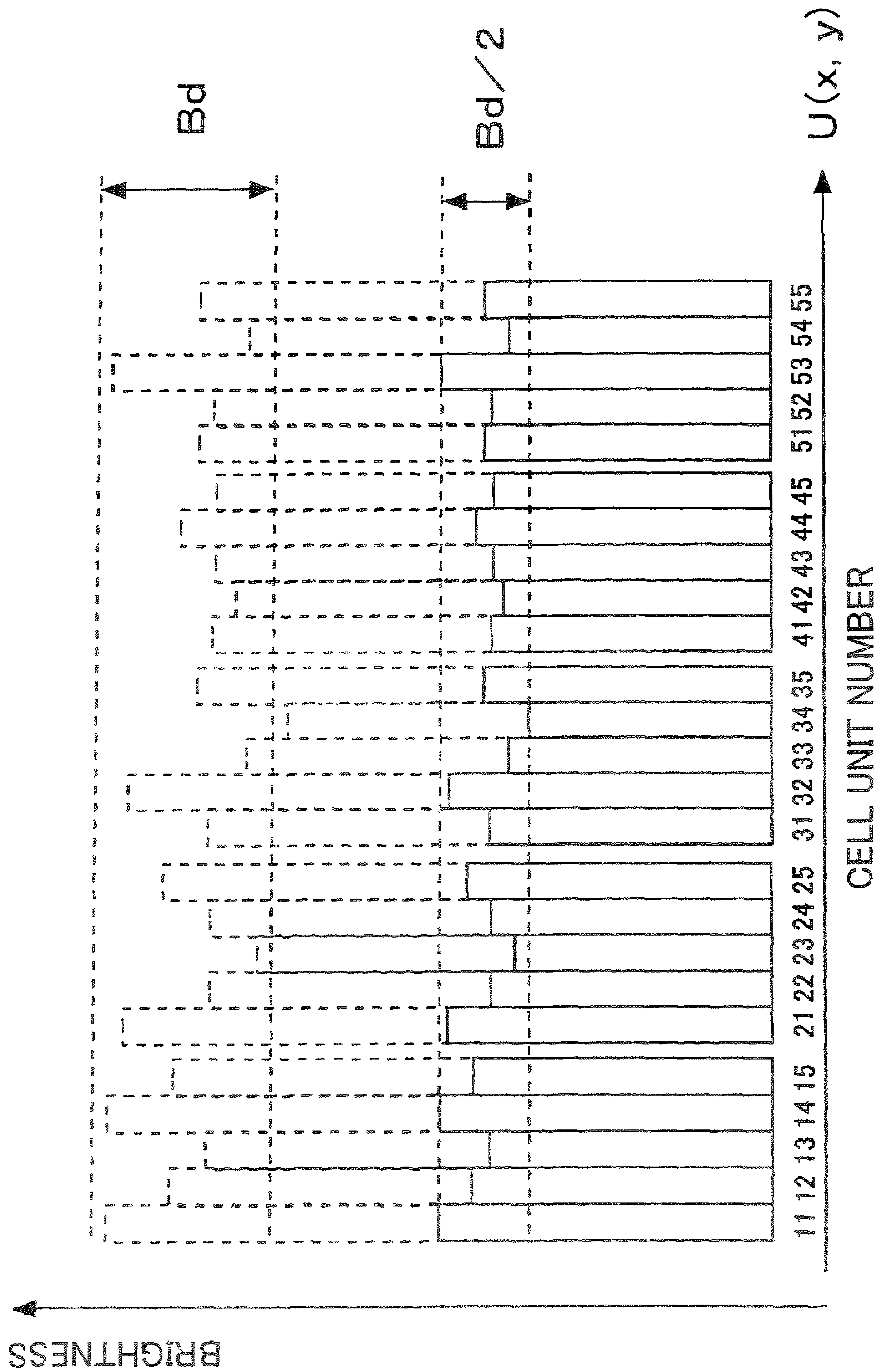

Bd
Bd/2
U(x, y)
11 12 13 14 15 21 22 23 24 25 31 32 33 34 35 41 42 43 44 45 51 52 53 54 55
CELL UNIT NUMBER
BRIGHTNESS

Fig.13

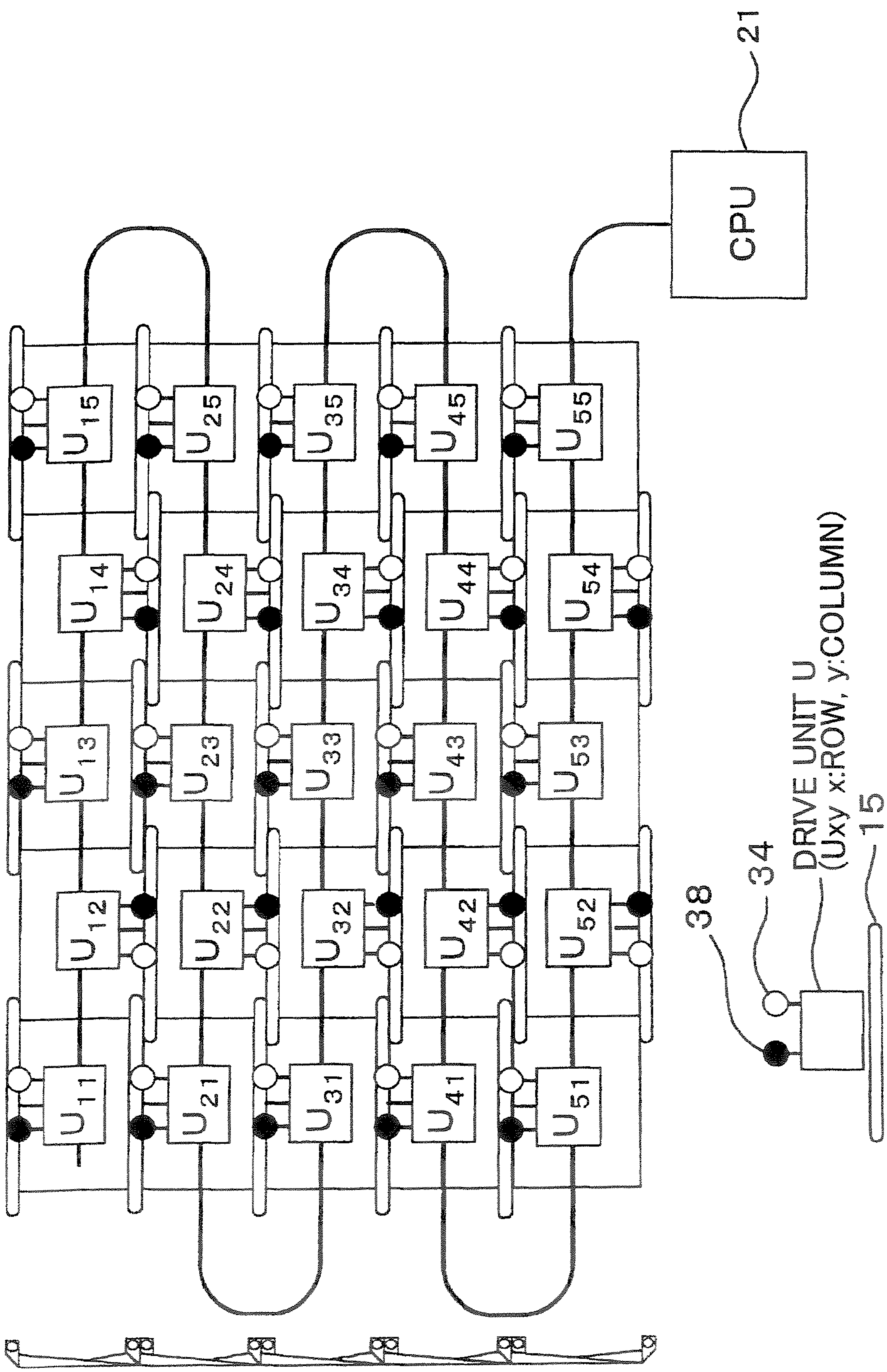
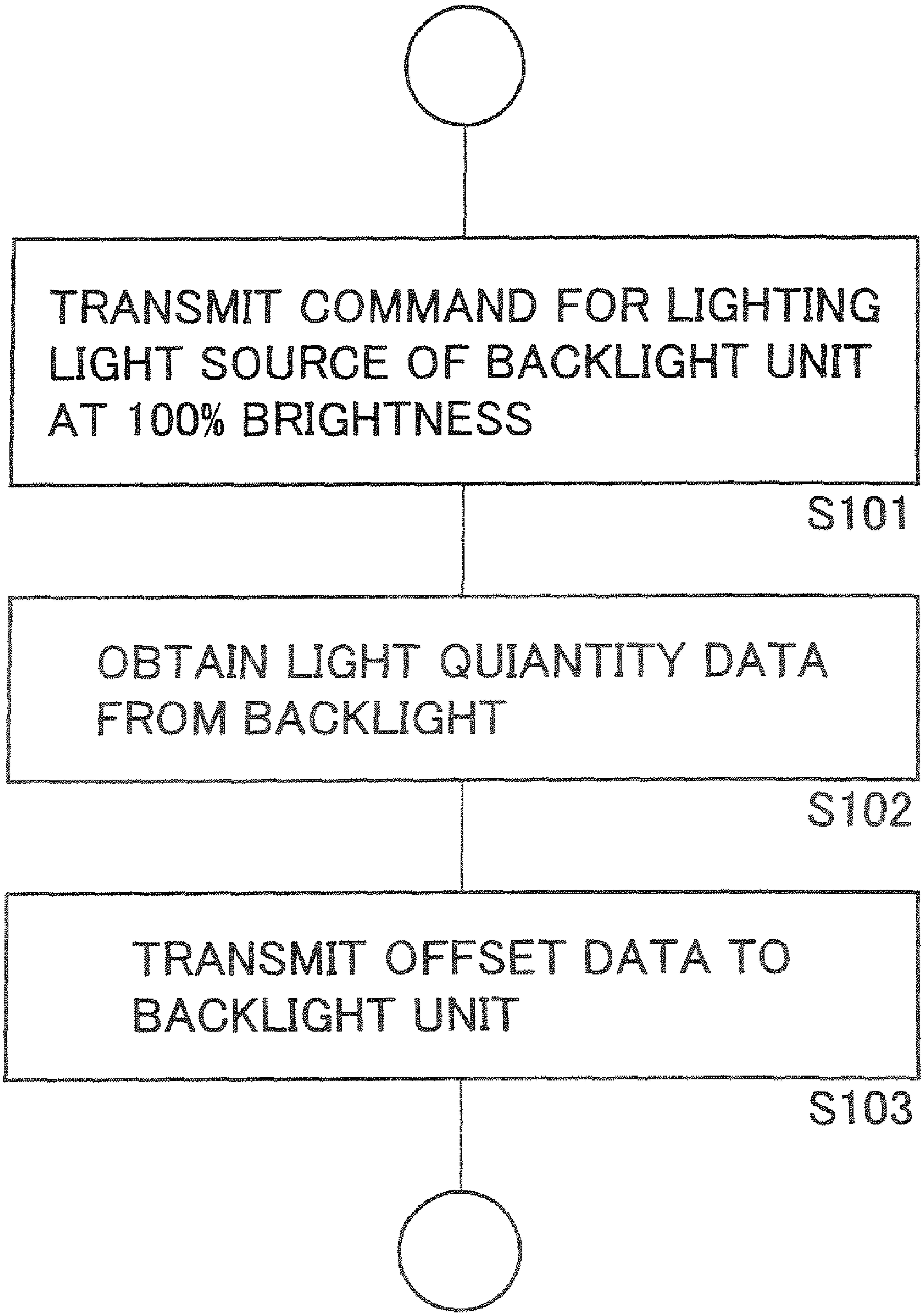

21
CPU
U_{11}
U_{12}
U_{13}
U_{14}
U_{15}
U_{21}
U_{22}
U_{23}
U_{24}
U_{25}
U_{31}
U_{32}
U_{33}
U_{34}
U_{35}
U_{41}
U_{42}
U_{43}
U_{44}
U_{45}
U_{51}
U_{52}
U_{53}
U_{54}
U_{55}
38
34
DRIVE UNIT U
(Uxy x:ROW, y:COLUMN)
15

Fig.14

FIG.15


TRANSMIT COMMAND FOR LIGHTING LIGHT SOURCE OF BACKLIGHT UNIT AT 100% BRIGHTNESS
S101
OBTAIN LIGHT QUIANTITY DATA FROM BACKLIGHT
S102
TRANSMIT OFFSET DATA TO BACKLIGHT UNIT
S103

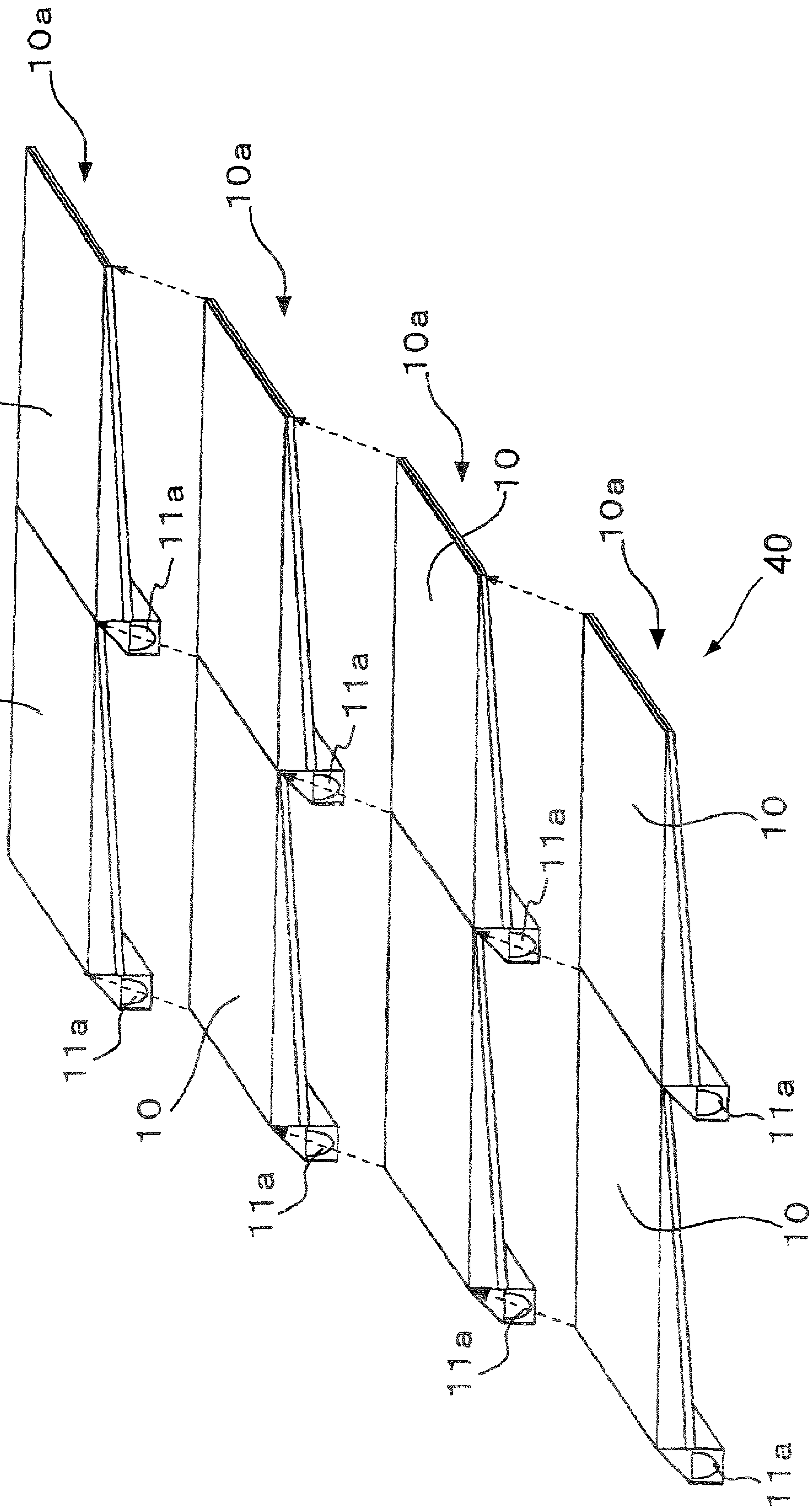

10a
10a
10a
10a
10
10
10
10
10
10
11a
11a
11a
11a
11a
11a
11a
11a
40

Fig.16

Fig.17A

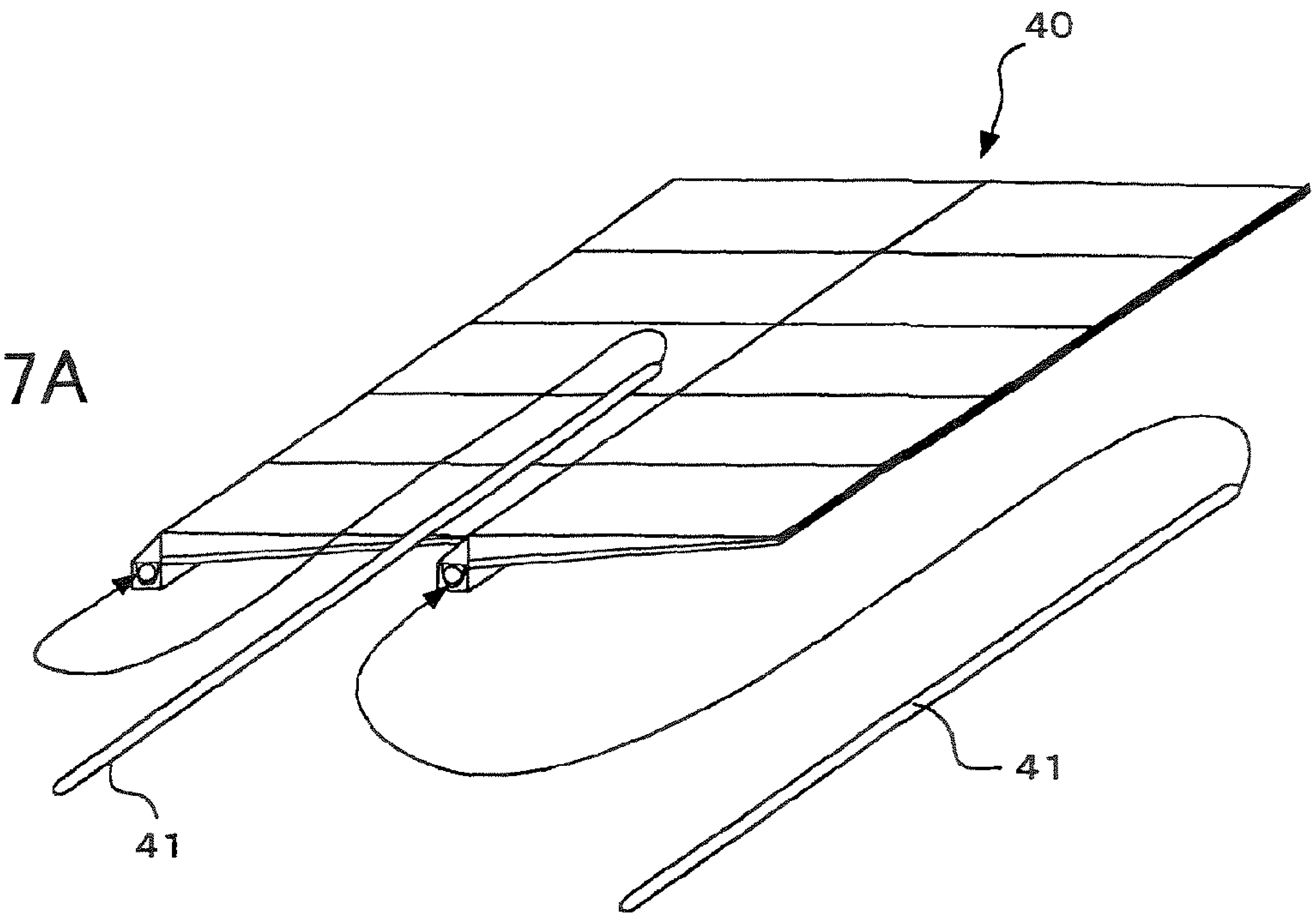


Fig.17B

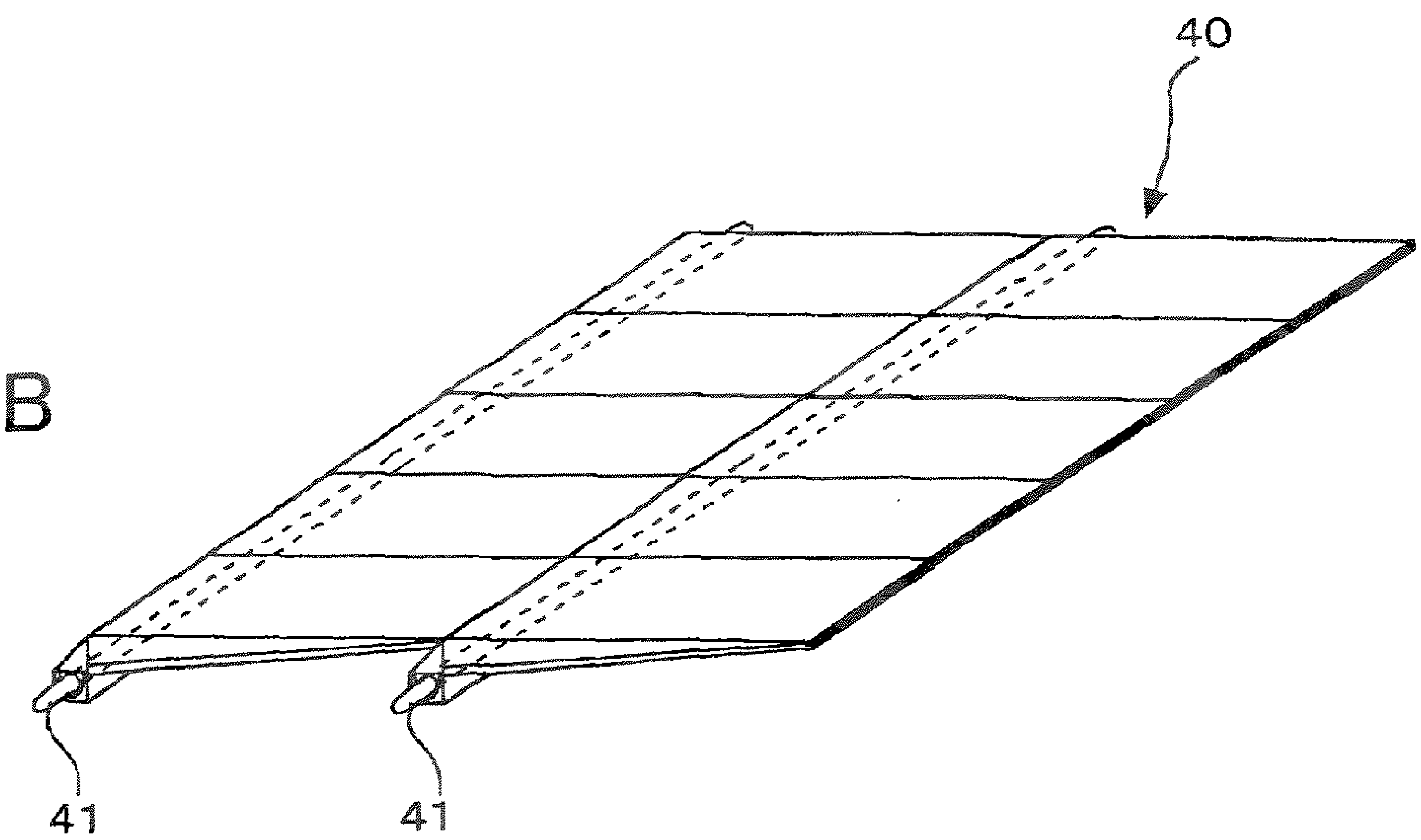
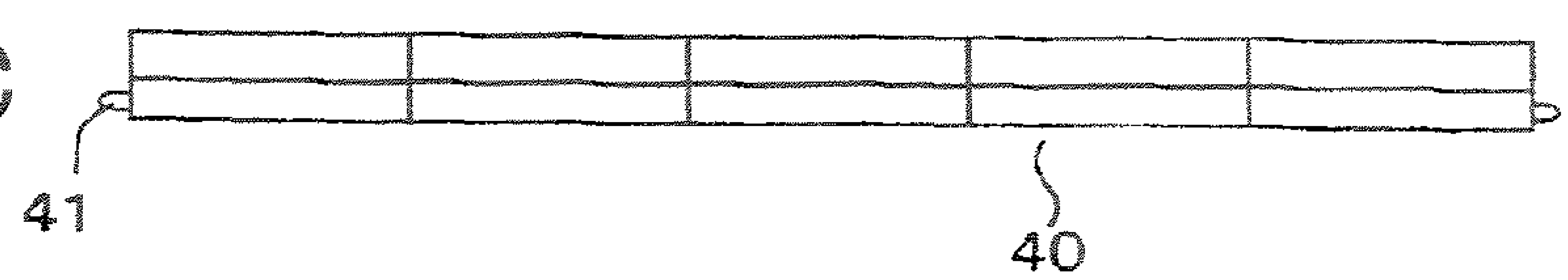


Fig.17C



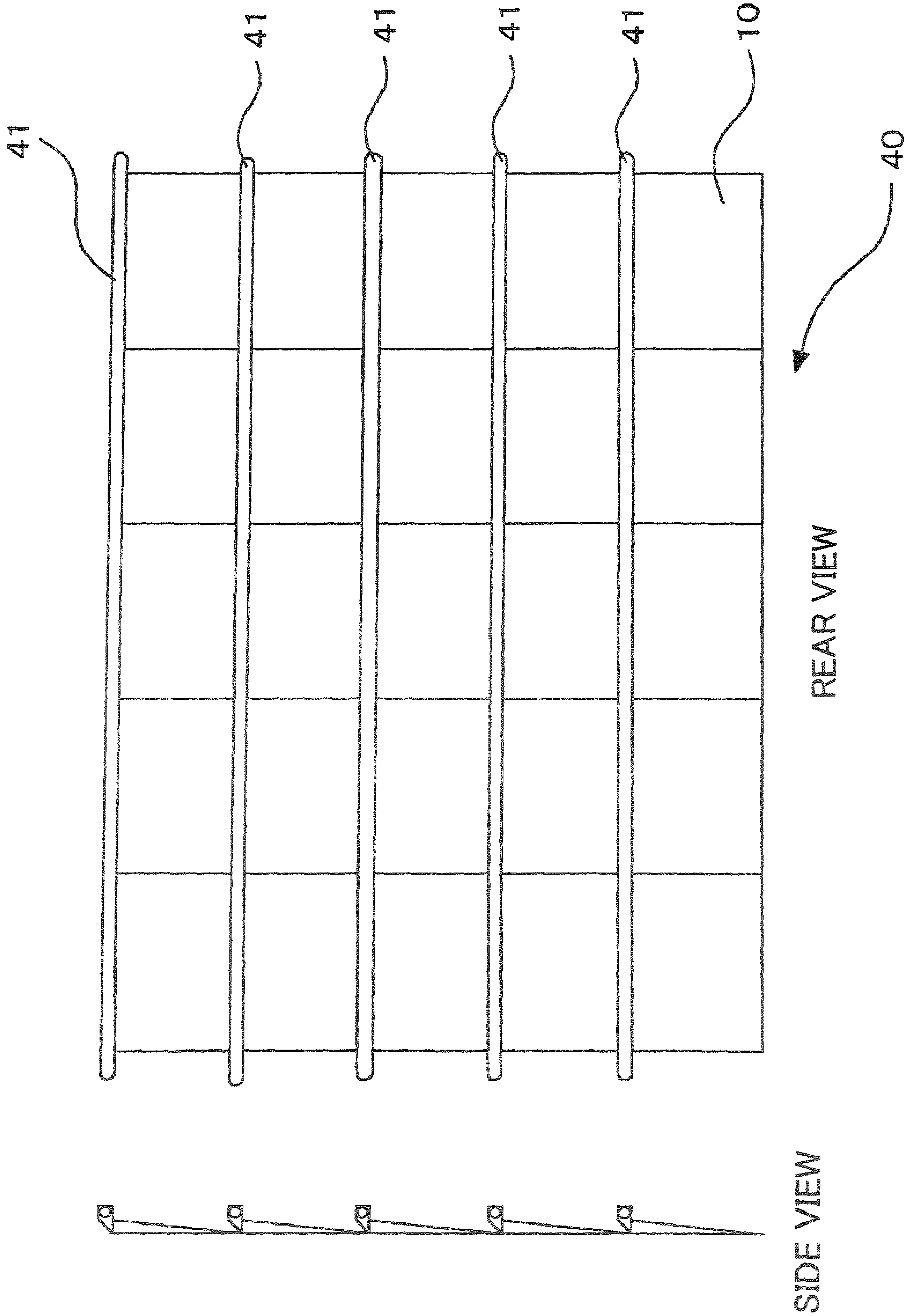


Fig.18

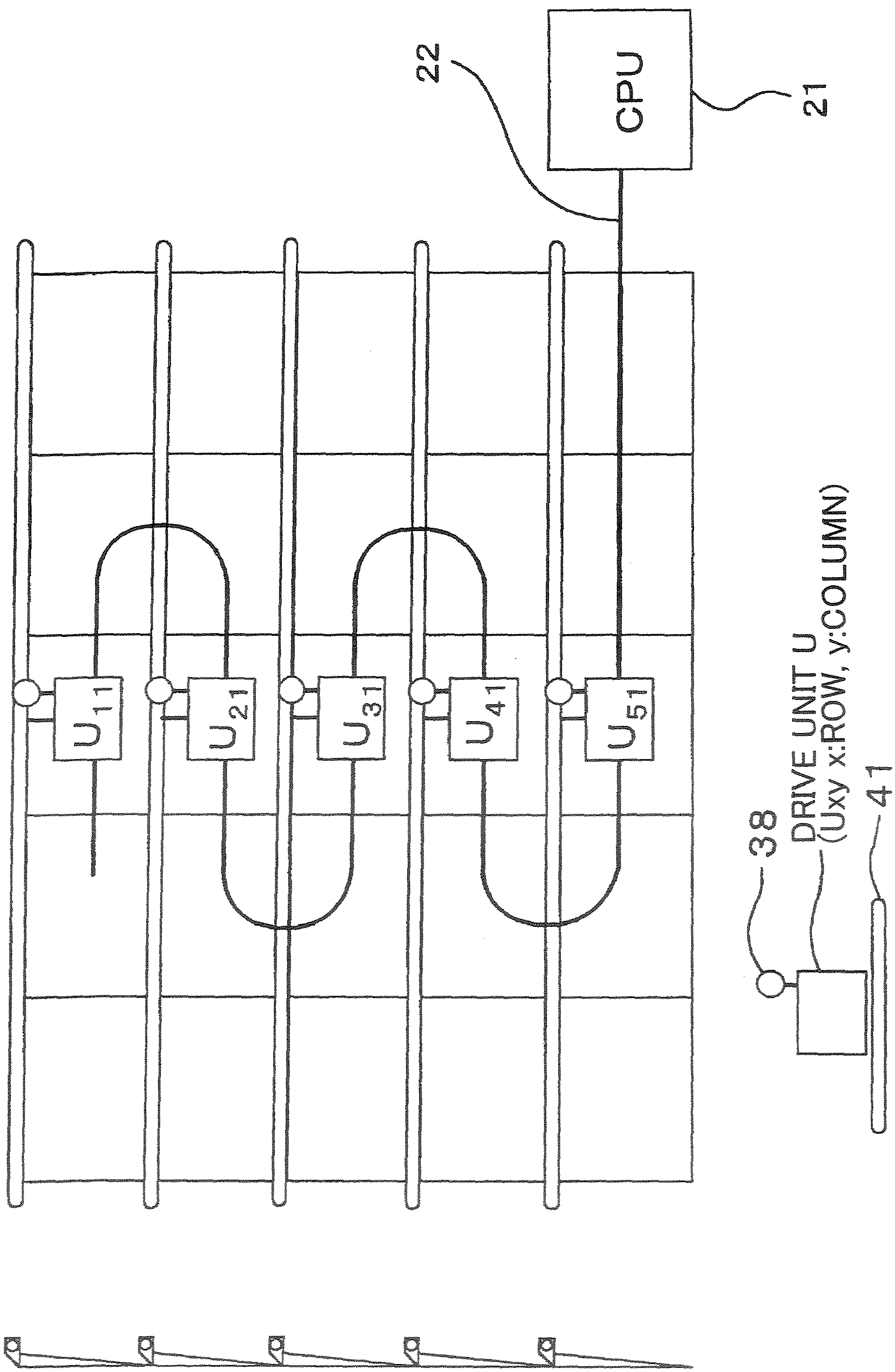

22
CPU
21
U_{11}
U_{21}
U_{31}
U_{41}
U_{51}
38
DRIVE UNIT U
(Uxy x:ROW, y:COLUMN)
41

Fig.19

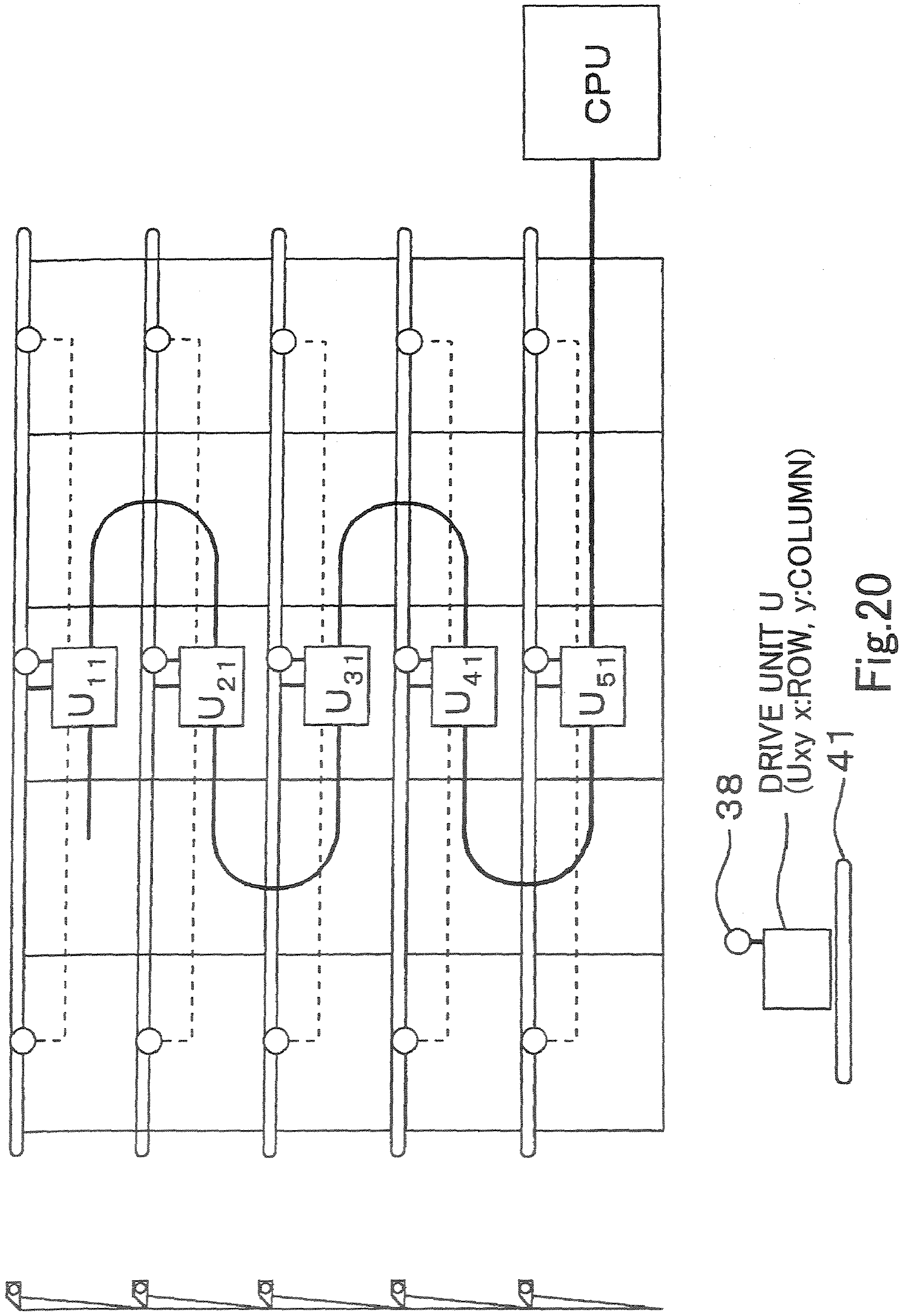


Fig.20

Fig.21A

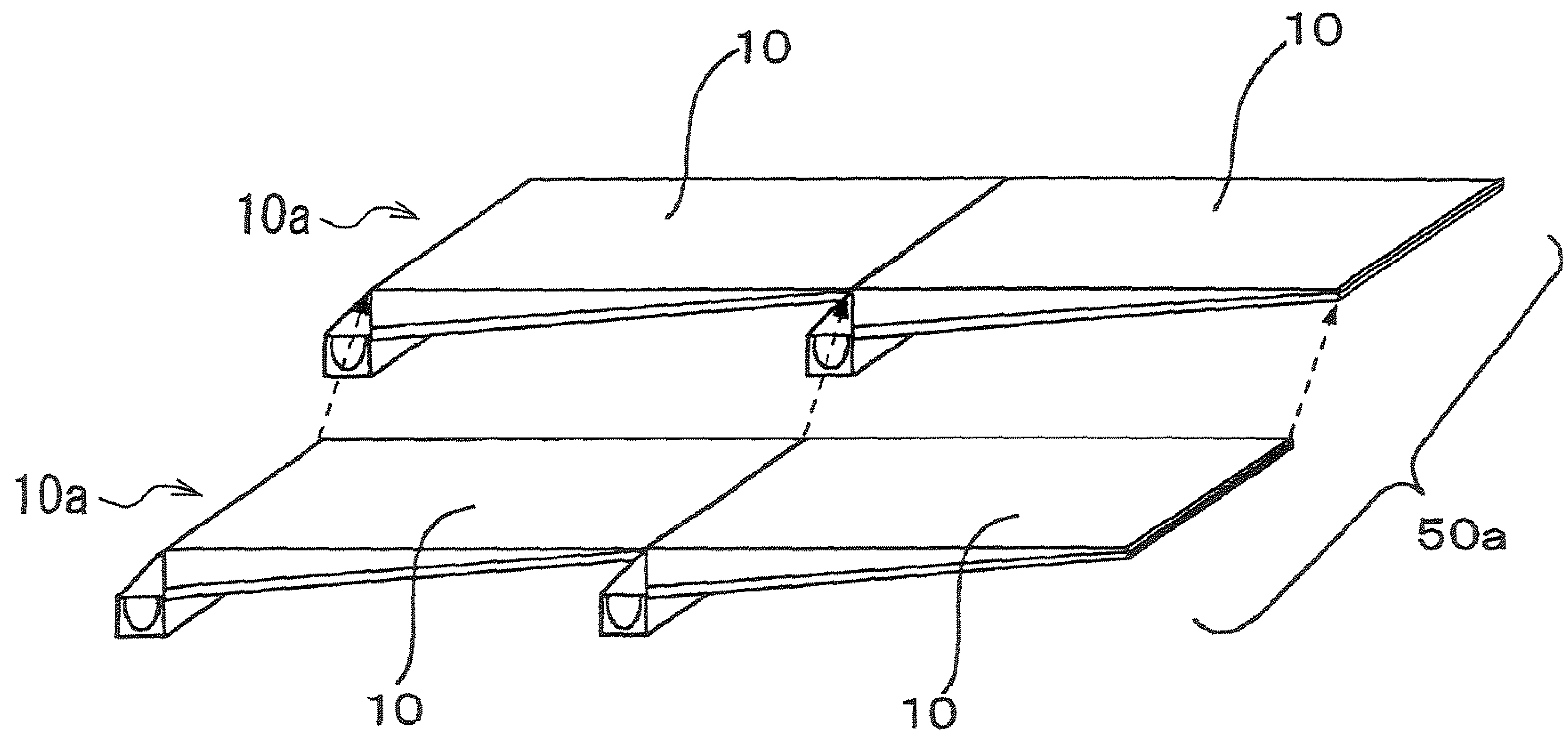


Fig.21B

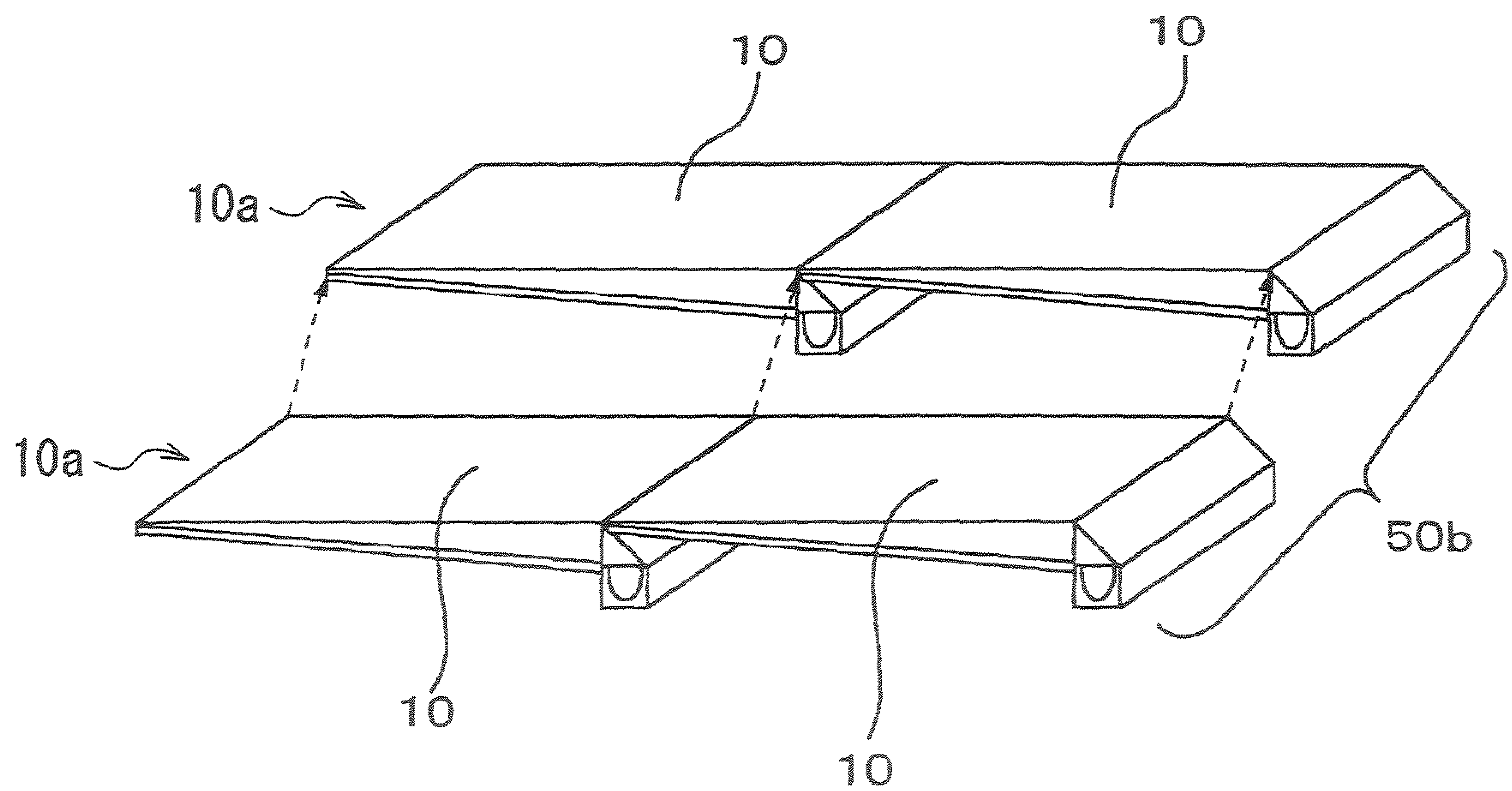


Fig.22A

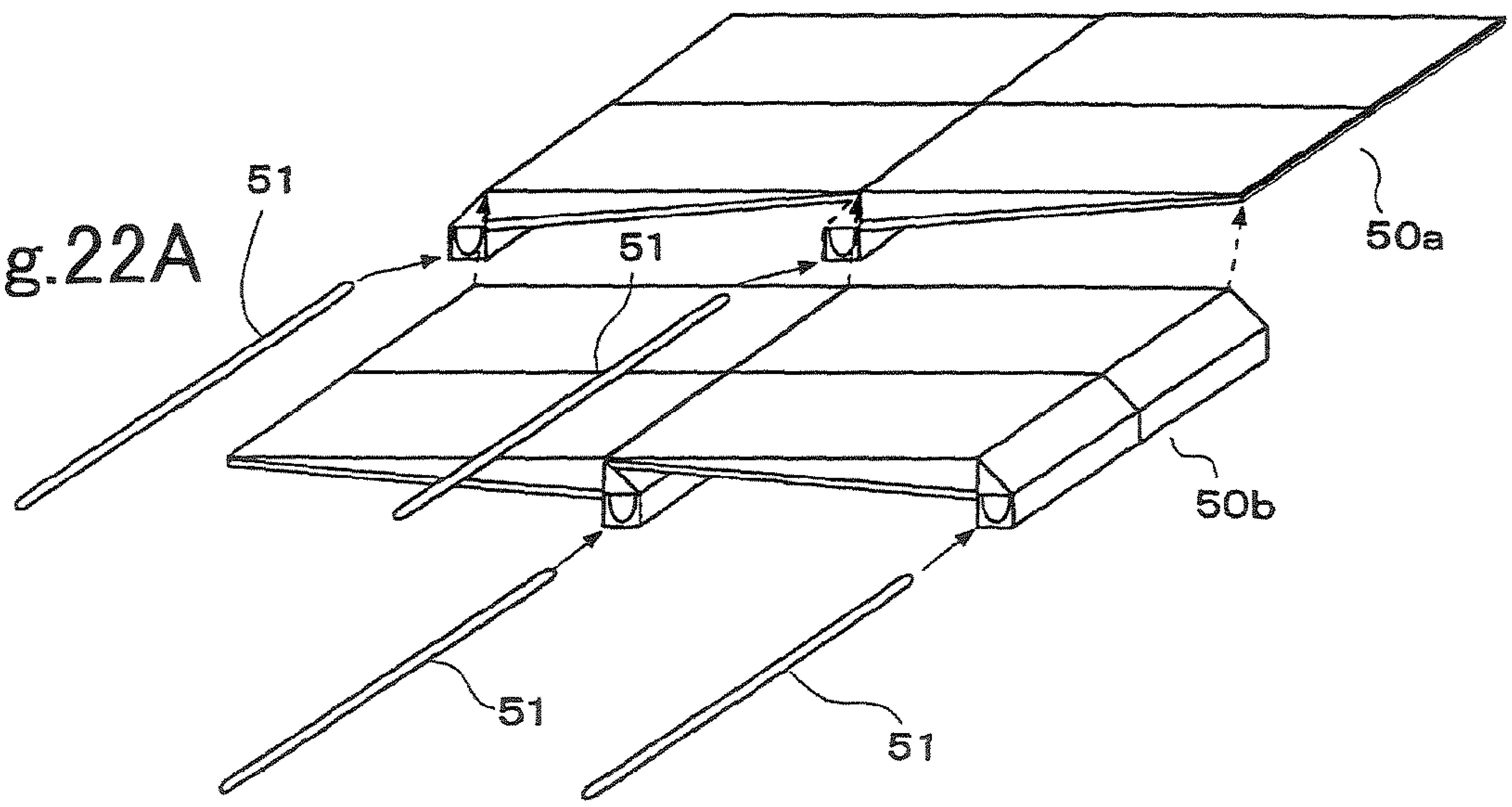


Fig.22B

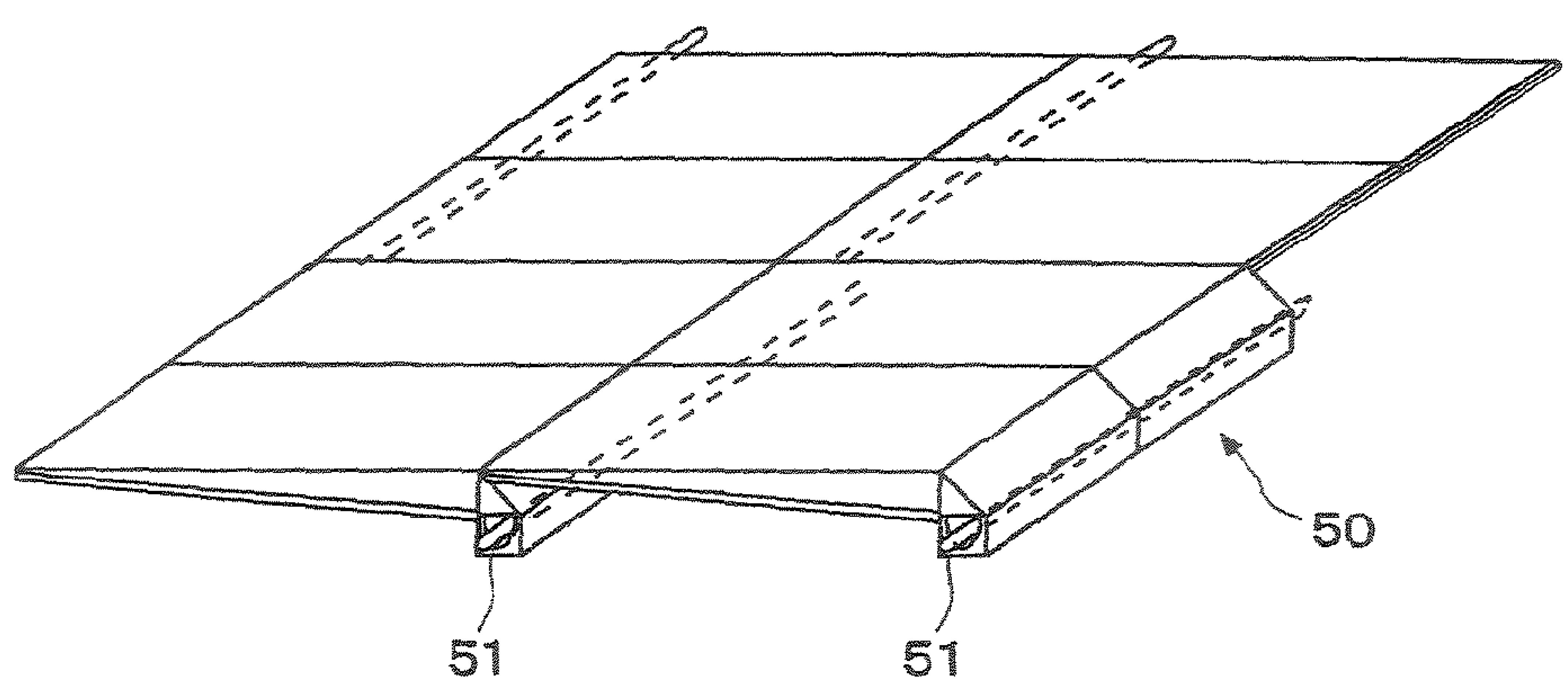
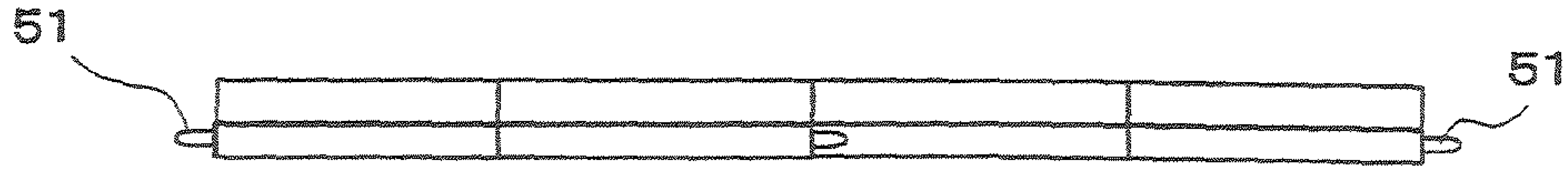


Fig.22C



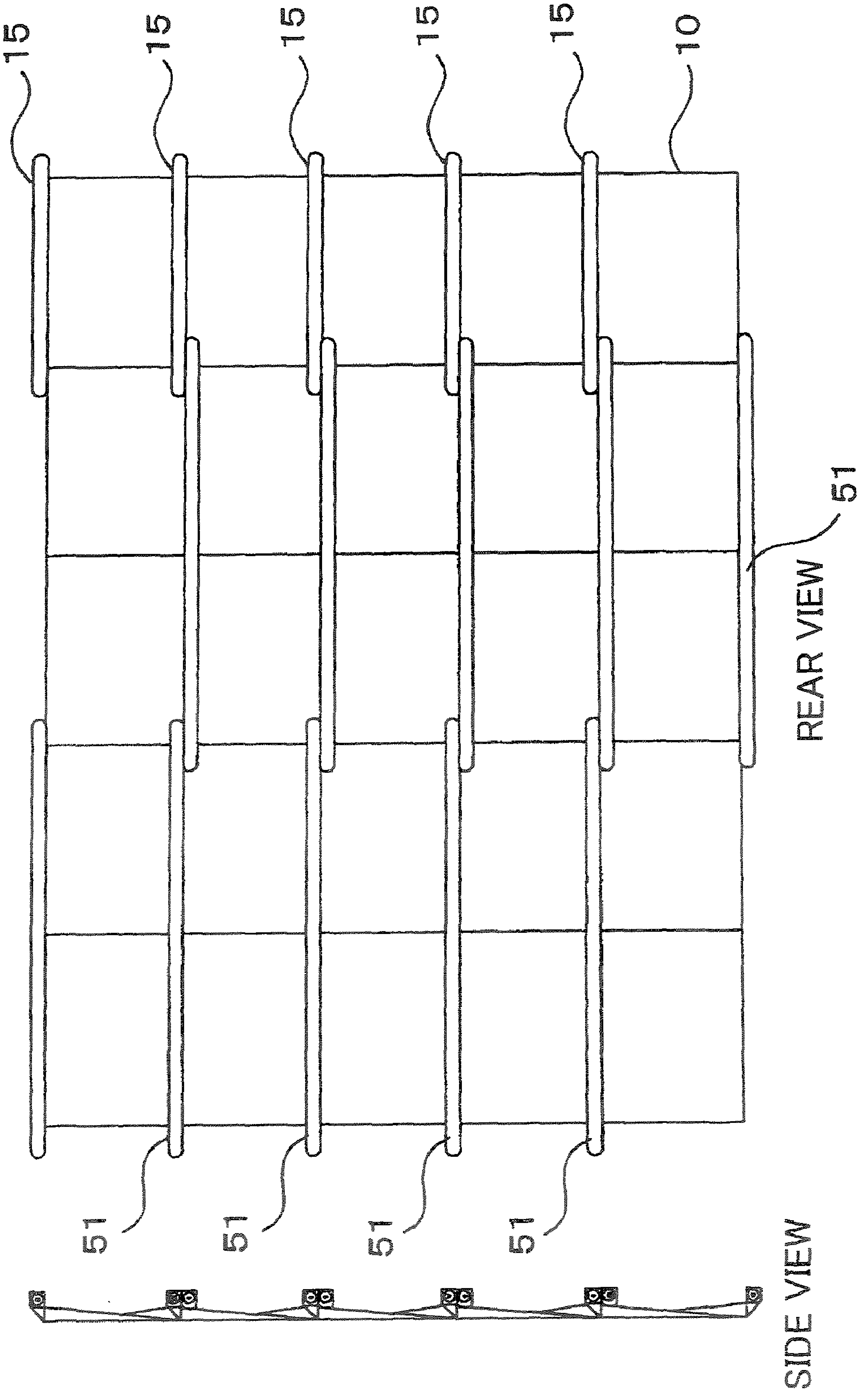


Fig.23

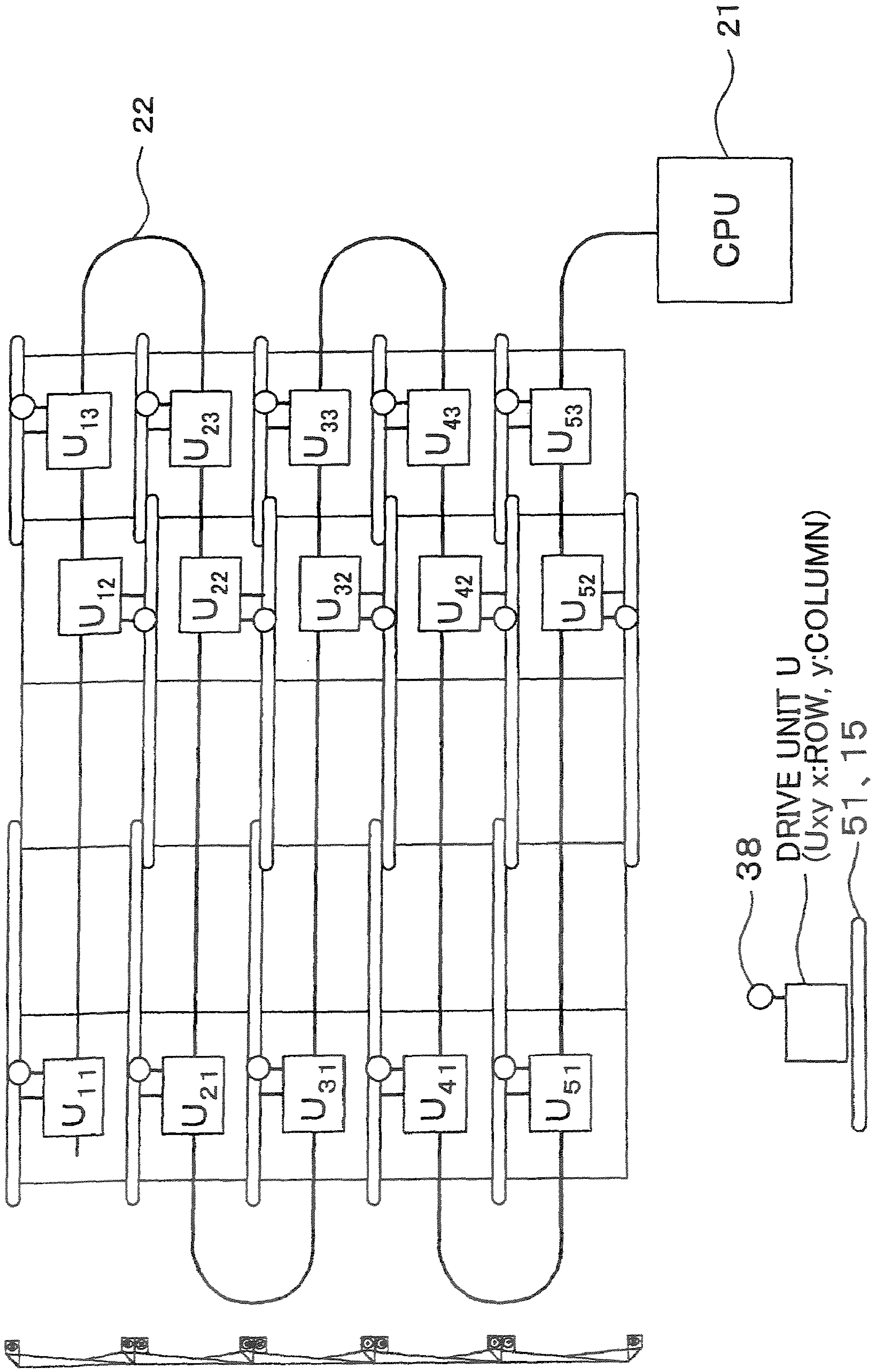
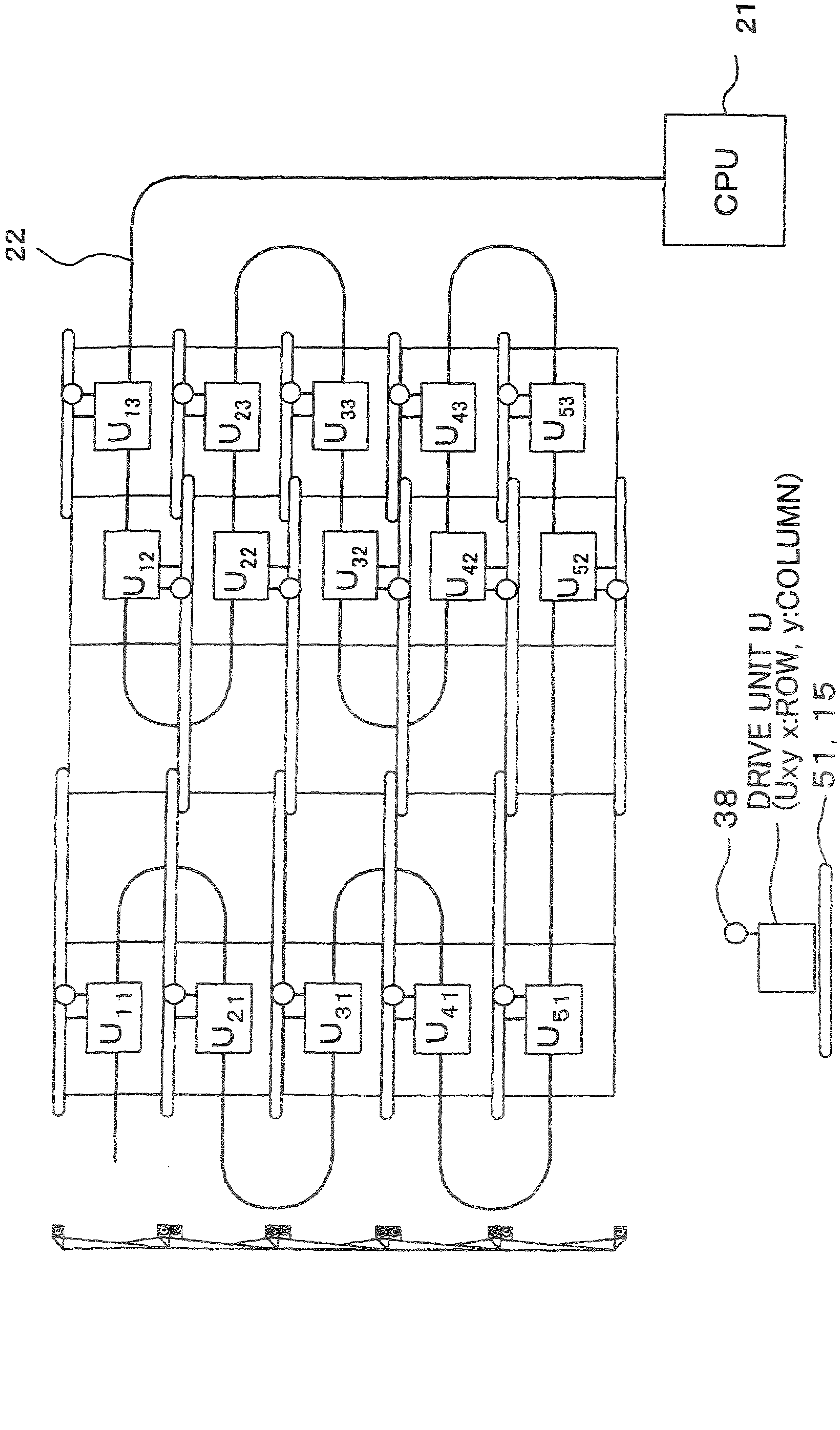

22
21
CPU
U13
U23
U33
U43
U53
U12
U22
U32
U42
U52
U11
U21
U31
U41
U51
38
DRIVE UNIT U
(Uxy x:ROW, y:COLUMN)
51、15

Fig.24



21
CPU
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DRIVE UNIT U
(Uxy x:ROW, y:COLUMN)
51, 15

Fig.25

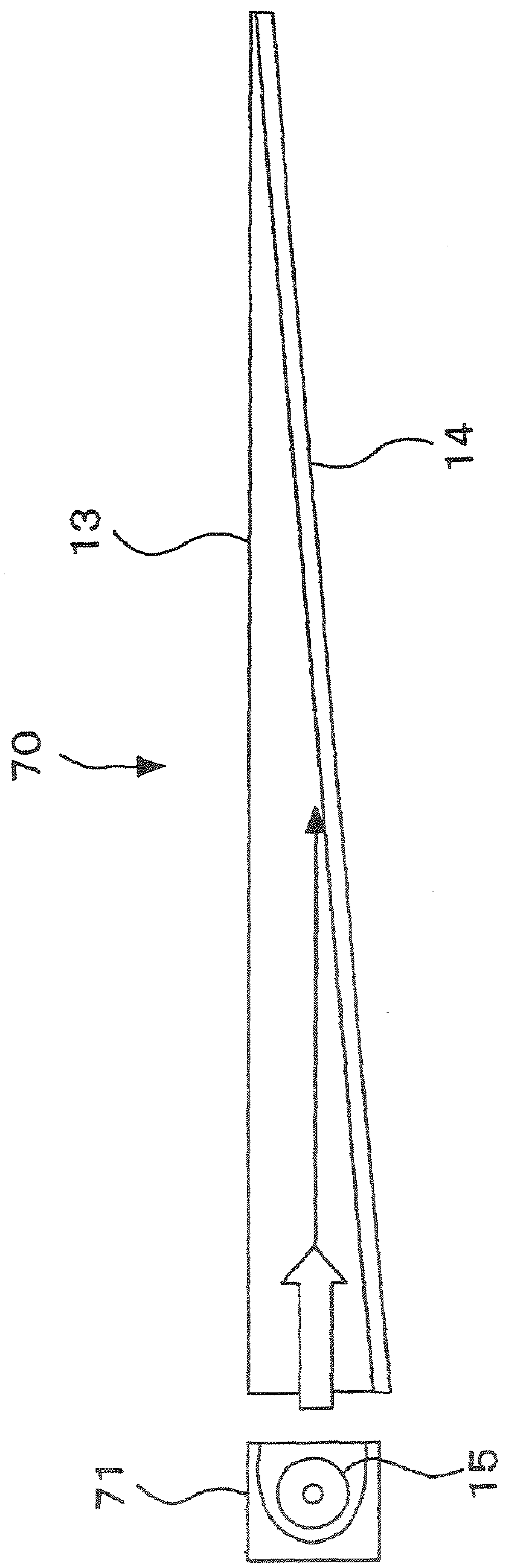


Fig.26A

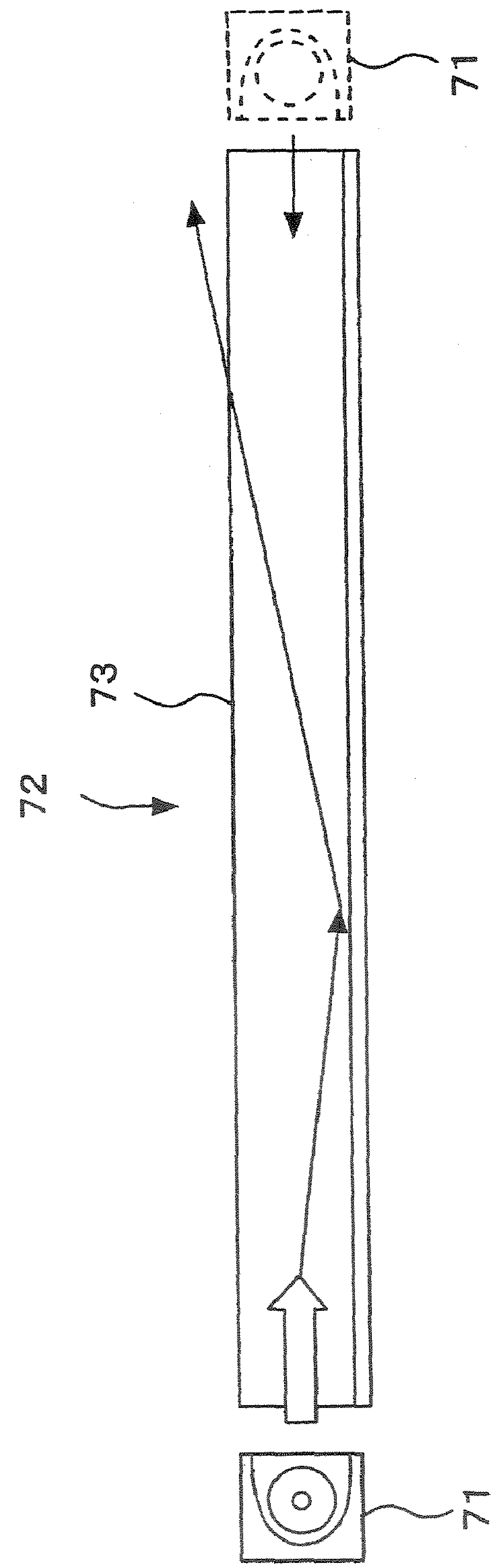


Fig.26B

Fig.27A

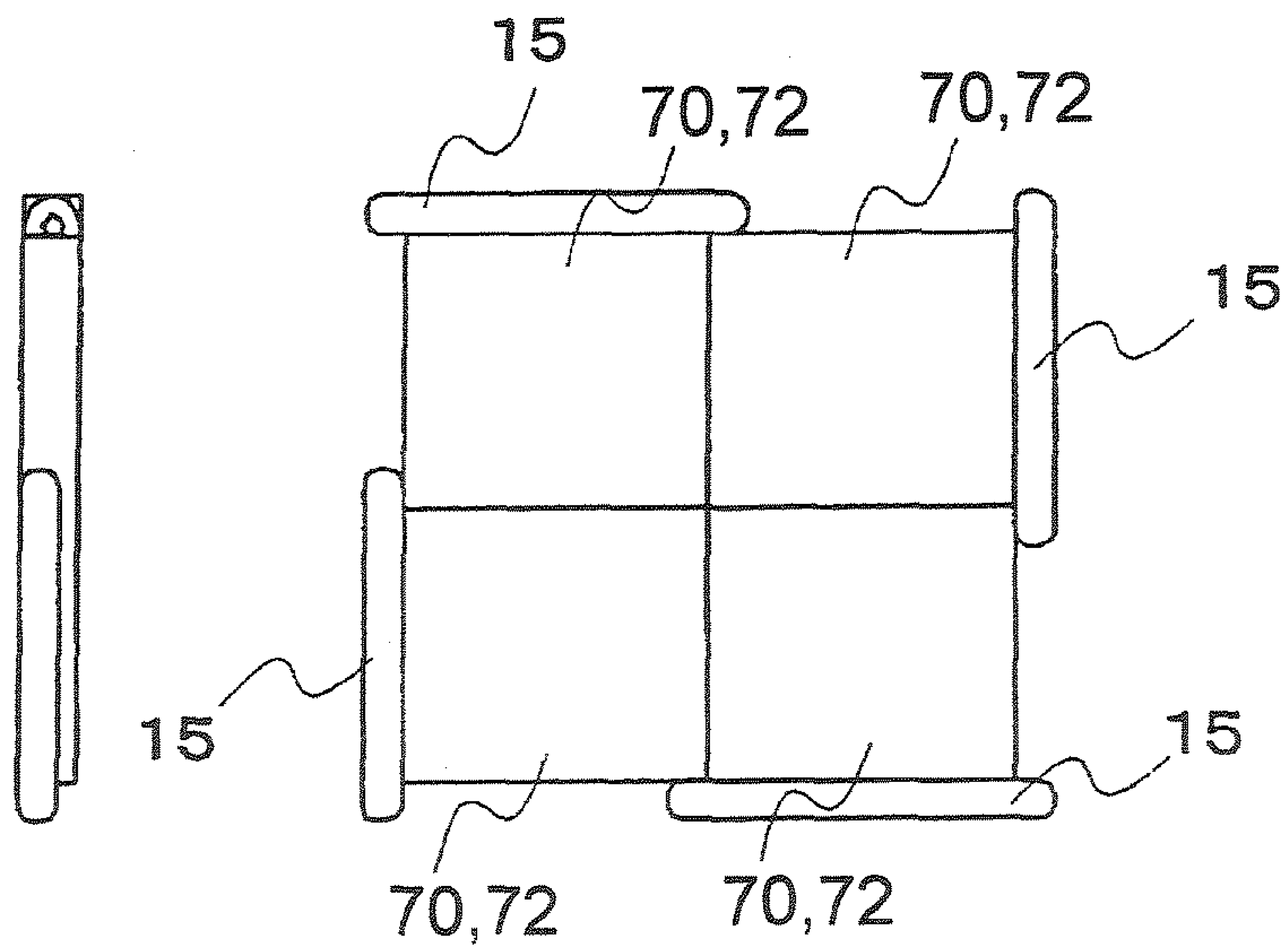
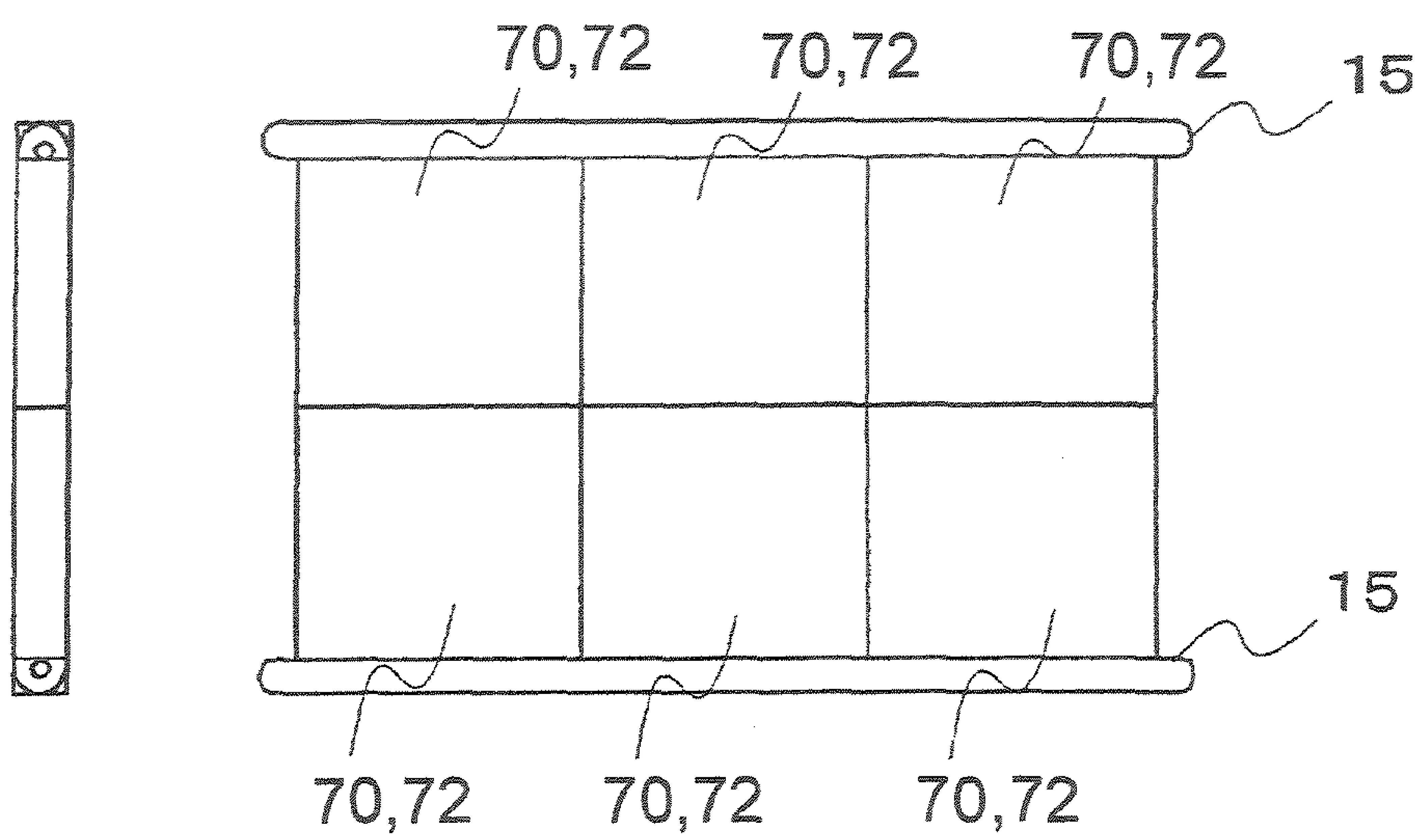


Fig.27B



BACKLIGHT, BACKLIGHT DRIVE APPARATUS, DISPLAY APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a divisional application of and claims the benefit of priority under 35 U.S.C. §120 for U.S. Ser. No. 10/511,706, filed Oct. 15, 2004, pending, which is a National Stage application of PCT/JP2004/001213, filed Feb. 5, 2004 and claims benefit of priority under 35 U.S.C. §119 from JP 2003-046406, filed Feb. 24, 2003, the entire contents of each of which are incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to, for example, a backlight which illuminates a liquid crystal panel from the rear, a backlight drive apparatus which drives such a backlight, and a display apparatus which is arranged to have such a backlight.

BACKGROUND OF THE ART

In recent years, as for a transmissive type liquid crystal display apparatus using a liquid crystal panel which is widely spread as a display apparatus of a television receiver etc., research and development for enlarging a liquid crystal display apparatus have been performed actively.

As a prior literature for realization of enlarging the liquid crystal display apparatus, a liquid crystal display apparatus is proposed in which a plurality of liquid crystal panels are joined together on the same plane and tiled so as to enlarge a liquid crystal panel, for example (Japanese Patent Application Publication No. H10-096911).

In the transmissive type liquid crystal display apparatus, it is necessary to provide a backlight for irradiating the liquid crystal panel with light from the rear side. For this reason, such liquid crystal display apparatuses can be classified roughly into a bottom backlight system and an edge light (side light) system, according to a structure of the backlight (Japanese Patent Application Publication No. 2001-266605).

In a small-sized liquid crystal display apparatus having a size of approximately 15 inches, the edge light system with which thickness of the backlight can be made thin is employed widely. For example, a backlight with a thickness of approximately 5 mm is realized and put into practical use.

However, in a backlight of the edge light system such as mentioned above, light is incident to a side edge (a side surface) of a light guide plate, and uniform light is emitted from an upper surface side of the light guide plate to the liquid crystal panel, so that a usage efficiency of the light is bad.

For this reason, when the backlight of a conventional side edge system illuminates a large-sized liquid crystal display apparatus having a size of 20 inches or more, for example, there is a disadvantage that the whole liquid crystal panel can not be illuminated uniformly with light of high brightness.

In other words, for example, when the backlight of the large-sized liquid crystal display apparatus is constructed by way of the edge light method, it is conceivable to use a light source of much higher brightness than a light source which is used for a conventional liquid crystal display apparatus with a size of approximately 15 inches. However, such a light source of high brightness does not exist at present.

Therefore, in order to attain high brightness of the large-sized liquid crystal display apparatus, there is only a way that a lot of (for example, three or more) fluorescence tubes are arranged at a side edge of the light guide plate, for securing a

quantity of light. There is a limit in obtention of the brightness for displaying a television image. Incidentally, there is no description of a structure of the backlight in the Japanese Laid-open Patent No. H10-096911.

Moreover, when a lot of fluorescence tubes are arranged as the light source on the side edge of the light guide plate so that the light of the fluorescence tubes is taken into the light guide plate, an acrylic resin which forms the light guide plate becomes thick. Thus, when the backlight of a large-sized liquid crystal display apparatus is realized by the side edge, there is a disadvantage that its weight becomes very heavy.

Then, the present invention is invented in view of the points as described above, and provides a backlight suitable for the large-sized liquid crystal display apparatus, the backlight drive apparatus for driving such a backlight and the display apparatus arranged to have such a backlight.

DISCLOSURE OF THE INVENTION

In order to attain the above-mentioned aims, a backlight of the present invention is formed by combining a plurality of backlight units with respect to a lighting surface which illuminates the back of a video display unit formed by a single panel.

According to the present invention, in the backlight for illuminating the video display unit formed by the single panel, it is possible to form a large-sized backlight by combining a plurality of backlight units in the shape of a plane.

Moreover, a display apparatus of the present invention comprises a backlight formed by combining a plurality of backlight units, a video display unit which is arranged on the lighting side of the backlight and formed by one or a plurality of video display panels, and a diffusion board arranged apart from the backlight and between the backlight and the video display unit.

Thus, according to the present invention, by arranging the diffusion board in the position which is apart from the backlight and between the backlight and the video display unit, even when the backlight is formed by combining the plurality of the backlight units, it becomes possible to prevent brightness unevenness from occurring at a junction section of the backlight units.

Moreover, the drive apparatus for the backlight formed by combining the plurality of backlight units of the present invention comprises a drive unit which is provided for each backlight unit and performs drive control of each backlight unit, and a drive control unit which performs drive control of the drive unit.

Thus, according to the drive apparatus for the backlight of the present invention, the backlight units which constitute the backlight are driven by respective drive units and the drive control unit controls the backlight units, so that the whole backlight can be controlled.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an overall view of a liquid crystal display apparatus of a preferred embodiment in accordance with the present invention;

FIG. **2** is an exploded view of the liquid crystal display apparatus of the preferred embodiment;

FIG. **3** is a side view of the liquid crystal display apparatus of the preferred embodiment;

FIG. **4** is an overall view of a backlight of a first preferred embodiment;

FIG. **5** is a view showing a partial structure of the backlight of the first preferred embodiment;

FIG. **6**A and FIG. **6**B are respectively an overall view and a back view showing a structure of a backlight unit of the first preferred embodiment;

FIG. **7**A and FIG. **7**B are cross-sectional views of the backlight unit of the first preferred embodiment;

FIG. **8**A and FIG. **8**B are views showing a structure of a pair of units which are formed by combining the backlight units of the first preferred embodiment;

FIG. **9** show a rear view and a side view of a structure of the whole backlight of the first preferred embodiment;

FIG. **10** are views showing an example of the whole drive apparatus which drives the backlight of the first preferred embodiment;

FIG. **11** is a block diagram of a structure of a drive unit which drives the backlight unit which constitutes the backlight of the first preferred embodiment;

FIGS. **12**A and **12**B are views for explaining a system which corrects automatically brightness unevenness of the backlight of the first preferred embodiment;

FIG. **13** is a graph for explaining a system which performs brightness control of the backlight of the first preferred embodiment;

FIG. **14** are views showing another example of a structure of the drive apparatus which drives the backlight of the first preferred embodiment;

FIG. **15** is a flow chart showing a process performed by an external CPU for driving the backlight of the first preferred embodiment;

FIG. **16** is a view showing an example of a combination of the backlight units which constitute the backlight of a second preferred embodiment;

FIG. **17**A through FIG. **17**C are views showing a structure of the backlight units of the second preferred embodiment;

FIG. **18** show a rear view and a side view in which the whole backlight of the second preferred embodiment is constituted;

FIG. **19** show an example of a structure of the drive apparatus which drives the backlight of the second preferred embodiment;

FIG. **20** are views showing another example of a structure of the drive apparatus which drives the backlight of the second preferred embodiment;

FIG. **21**A and FIG. **21**B are views showing an example of a combination of the backlight units which constitute the backlight of a third preferred embodiment;

FIG. **22**A through FIG. **22**C are views showing a structure of the backlight units of the third preferred embodiment;

FIG. **23** show a rear view and a side view in which the whole backlight of the third preferred embodiment is constituted;

FIG. **24** are views showing an example of a structure of the drive apparatus for driving the backlight of the third preferred embodiment;

FIG. **25** are views showing another example of a structure of the drive apparatus for driving the backlight of the third preferred embodiment;

FIG. **26**A and FIG. **26**B are views showing another example of a structure of the backlight unit which constitutes the backlight;

FIG. **27**A and FIG. **27**B are examples of structures of the backlight using the backlight units as shown in FIGS. **26**A and **26**B.

BEST MODE FOR IMPLEMENTING THE INVENTION

Hereinafter, preferred embodiments of the present invention will be described.

In addition, the preferred embodiments will be described in the following order:

1. Structure of Liquid Crystal Display Apparatus

2. Backlight

2-1 Structure of Backlight

2-2 Structure of Backlight Unit

2-3 Drive Apparatus of Backlight 3. Backlight of Second Preferred Embodiment 4. Backlight of Third Preferred Embodiment

1. Structure of Liquid Crystal Display Apparatus

Firstly, a liquid crystal display apparatus of a preferred embodiment will be described by using FIGS. **1**-**3**.

FIG. **1** is an overall view of the liquid crystal display apparatus of the preferred embodiment, FIG. **2** is an exploded view, and FIG. **3** is a side view.

As shown in these FIG. **1** through FIG. **3**, a liquid crystal display apparatus **1** of the preferred embodiment is arranged to have a backlight **2** under a liquid crystal panel **3**.

Further, between the backlight **2** and the liquid crystal panel **3**, a transparent acrylic board **4** and a diffusion board **5** are arranged sequentially from the backlight **2** side.

The backlight **2** is formed such that a plurality of backlight units **10**, **10**, . . . are arranged in a planar shape (a shape of tiles). In addition, a structure of the backlight **2** will be described in detail later.

The liquid crystal panel **3** modulates light which is emitted from the backlight **2** so as to form required image light.

The transparent acrylic board **4** is provided to prevent a shadow from taking place at a combination section of the backlight units **10**, when the backlight **2** is arranged in the planar shape by combining the plurality of backlight units **10**, **10**, . . . , for example.

The diffusion board **5** diffuses the light emitted from the backlight **2** so as to equalize the light irradiating the liquid crystal panel **3**. A thickness of the diffusion board **5** in this case is set to a thickness capable of equalizing the light irradiating the liquid crystal panel **3**.

In addition, a board thickness D of the transparent acrylic board **4** and a distance d between the backlight **2** and the diffusion board **5** as shown in FIG. **3** may only be set properly to a distance avoiding the shadow at the combination section of the backlight unit **10**.

Further, if the distance d between the backlight **2** and the diffusion board **5** is caused to be larger, it is possible to prevent the shadow of the combination section of the backlight units **10**, without necessarily forming the transparent acrylic board **4**.

2. Backlight of First Preferred Embodiment

2-1 Structure of Backlight

Next, the backlight of a first preferred embodiment of the present invention will be described by using FIG. **4** and FIG. **5**.

FIG. **4** is an overall view of the backlight of the first preferred embodiment. FIG. **5** is a view showing a partial structure.

The backlight **2** as shown in FIG. **4** is formed by combining the plurality of backlight units **10**, **10**, . . . in the planar shape. In other words, the backlight **2** for illuminating the liquid crystal panel **3** of single structure from the back is formed by combining the plurality of backlight units **10**, **10**, . . . in the planar shape.

As a method of combining the backlight units **10**, **10**, . . . in this case, as shown in FIG. **5**, a pair of units **10***a* having combined two backlight units **10** and **10** in the same direction is considered as one backlight unit by arranging these alternately, i.e., arranging these in different directions which differ from one another by 180 degrees, so that the backlight **2** as shown in FIG. **4** is formed.

2-2 Structure of Backlight Unit

Next, a structure of the backlight unit will be described by using FIG. **6**A and FIG. **6**B, and FIG. **7**A and FIG. **7**B.

FIG. **6**A and FIG. **6**B are views showing the structure of the backlight unit, and FIG. **6**A is an overall view of the backlight unit, and FIG. **6**B is a back view. Further, FIG. **7**A is a cross-sectional view and FIG. **7**B is an exploded cross-sectional view.

Moreover, FIG. **8**A and FIG. **8**B are views for explaining a structure of the pair of units which are formed by combining two backlight units. FIG. **8**A is an overall view of the pair of units, and FIG. **8**B is an enlarged view of the combination section.

As shown in FIG. **6**A and FIG. **6**B, and FIG. **7**A and FIG. **7**B, the backlight unit **10** of the preferred embodiment comprises a light source unit **11**, a reflective prism **12**, a light guide plate **13**, and a condensing processed surface **14**.

The light source unit **11** is formed of, for example, aluminum or glass, and is provided therein with a lamp accommodation section **11***a* of a substantially semi-circular shape for accommodating a fluorescence tube which is a light source **15**. Further, a light reflector (a condensing mirror) **11***b* for condensing light from the light source **15** and for emitting the light to the reflective prism **12** side is formed on a surface of the lamp accommodation section **11***a*.

A light reflector **11***b* is, for example, a light reflector which reflects the light from the light source **15**, and formed by way of vapor-deposition or pasting silver on a surface of a lamp accommodation section **11***a*, for example. In this case, both ends of the fluorescence tube, which is the light source **15** accommodated in the lamp accommodation section **11***a*, protrude from both sides of the light source unit **11**, as shown in FIG. **6**B.

The reflective prism **12** is formed of an acrylic resin, for example, and arranged for deflecting the light emitted from the light source unit **11** and for guiding it from a side of the light guide plate **13** to the inside. When the reflective prism **12** is so formed between the light source unit **11** and the light guide plate **13**, and an optical incidence portion of the light guide plate **13** is used as a prism input, then it is possible to arrange the light source unit **11** on the back of the light guide plate **13**, and to inject the light into a side surface (side) of the light guide plate **13** by means of the light source unit **11** arranged on the back, as can be seen from FIG. **7**B. In addition, although the light source unit **11** is arranged on a short side of the light guide plate **13** herein, it is also possible to arrange the light source unit **11** on a long side of the light guide plate.

The light guide plate **13** is formed of an acrylic resin having a diagonal size of several inches, for example. Further, the light guide plate **13** in this case is formed, for example, in a so-called wedge shape where a board thickness of the light guide plate **13** is not flat but formed to become thinner as it is away from the optical incidence portion as illustrated.

The condensing processed surface **14** has a processed surface which is formed so as to equalize light flux emitted from an upper boundary, which is a lighting side of the light guide plate **13**, and irradiating the liquid crystal panel **3**. For example, the processed surface is formed to be a Fresnel surface or is formed to be a reflective surface having a size corresponding to a distance from the optical incidence portion.

The light source **15** is, for example, a cold cathode lamp which is caused to be cylindrical, and is arranged so that a fluorescent material is excited by ultraviolet rays generated within a glass tube so as to externally emit visible light. In addition, a light emitting diode element (LED: Light Emitting Diode) can be used for the light source **15** other than the fluorescence tube.

As shown in FIG. **8**A and FIG. **8**B, the combination section of the pair of units **10***a* formed by combining two backlight units **10** and **10** in the same direction is as shown in FIG. **8**B. In other words, a shape of the reflective prism **12** attached to the light guide plate **13** of the backlight unit **10** is substantially triangular and a shape of the light guide plate **13** combined with this reflective prism **12** is wedge-shaped, so that a shape of an end of the light guide plate **13** is determined considering the shape of the reflective prism **12**.

If an angle of the back of the reflective prism **12** is 45 degrees, and if an angle of a tip side of the light guide plate **13** is 45 degrees or less, even when two sets of the backlight units **10** and **10** are combined in the same direction, then the light guide plates **13** and **13** of the backlight units **10** and **10** can be combined with each other without a gap, as shown in FIG. **8**A.

In addition, the shape of the light guide plate **13** is described as being wedge-shaped in the preferred embodiment, which is merely an example. When at least the shape of the end surface of the light guide plate **13** is combined with the back of the reflective prism **12**, it may only be a shape allowing the light guide plate **13** and **13** of the backlight units **10** and **10** to be combined without a gap.

However, as shown in FIG. **6**B, in this case, parts of the fluorescence tube, which is the light source **15**, protrude from both sides of the light source unit **11**. When the pair of units **10***a* in the same direction are arranged in the same direction, i.e., when the pair of units **10***a* and **10***a* are arranged such that the light source units **11** of the backlight unit **10** are brought into contact with each other, parts protruding from both the sides of the light source unit **11***s* are contacted, so that the pair of units **10***a* and **10***a* cannot be arranged without a gap.

Then, in the preferred embodiment, when the pair of units **10***a* and **10***a* are arranged, the pair of units **10***a* and **10***a* are alternately arranged as shown in FIG. **5**, so that the plurality of backlight units **10** and **10** are arranged in the planar shape without a gap as shown in FIG. **4**, to thereby realize the backlight **2**.

Thus, in this preferred embodiment, the backlight **2** for illuminating the liquid crystal panel **3** is formed by using the plurality of backlight units **10**, so that, for example, the backlight **2** can be realized which is capable of illuminating the whole liquid crystal panel **3** having a large size, such as 20 inches or more, with light of high brightness.

Further, if the backlight **2** is constructed in a manner as in the preferred embodiment, a size of the whole backlight is determined by a combination number of sheets of the backlight units **10** in both the vertical and horizontal directions, so that there is an advantage that components of the backlight **2** can be used commonly, from a small one to a large-sized one.

Moreover, in the preferred embodiment, the shape of the light guide plate **13** of the backlight unit **10** is caused to be wedge-shaped, and the thickness of the acrylic resin which is a material of the light guide plate **13** can be caused to be thin, so that even when the backlight of the large-sized liquid crystal display apparatus of 20 inches or more is constructed, for example, weight per unit area of the backlight can be caused to be light. In other words, even when the backlight **2** is enlarged, an increase in weight is only proportional to the area, whereby the backlight **2** can be caused to be lighter.

Further, if the reflective prism **12** is formed at the optical incidence portion of the light guide plate **13** which constitutes the backlight unit **10**, the light source unit **11** is arranged on the back of the light guide plate **13**, and a shape (angle) of the end part of the light guide plate **13** is set up considering the shape (angle) of the reflective prism **12**, then it becomes possible to combine the backlight units **10** and **10** without a gap even when the backlight units **10** and **10** are arranged in the same direction.

Thus, for example, the shadow of the combination section of the plurality of backlight units **10**, **10**, . . . can be prevented.

Further, even if there is a gap at the combination section of the backlight units **10** and **10**, when the liquid crystal display apparatus **1** is constructed in a manner as in the preferred embodiment, the shadow of the combination section of the backlight units **10** and **10** can substantially be inconspicuous by means of the transparent acrylic board **4** disposed between the backlight **2** and the diffusion board **5** or the distance d between the backlight **2** and the diffusion board **5**, whereby there is no difficulty in realizing the backlight when constructing the liquid crystal display apparatus **1**.

In addition, the number of sheets of the backlight units **10**, **10**, . . . which form the backlight **2** of the preferred embodiment may arbitrarily be set up according to the shape of the whole backlight **2** and the shape of the backlight unit **10**.

Further, for example, in case an image of 4:3 is displayed on the liquid crystal panel of an aspect ratio of 16:9, when the shape of the backlight unit **10** is set to a required size, for example, the backlight unit **10** for a part where an image is not displayed on the liquid crystal panel can be switched off to form a black screen.

2-3 Drive Apparatus of Backlight

Next, a drive apparatus for a backlight such as described above will be described using FIGS. **9** through **14**.

Here, it will be described assuming that backlight units are arranged vertically (column) and horizontally (row), five for each, so as to form the backlight.

FIG. **9** are a rear view and a side view of the thus constructed backlight. It can be seen from FIG. **9** that the light source **15** of the backlight units **10** which form the backlight **2** are arranged alternately with respect to the light guide plate **13**.

The drive apparatus for driving the above-mentioned backlight **2** is as shown in FIG. **10**. In this case, a drive unit Uxy (x: row, y: column) is formed for each backlight unit **10** which forms the backlight **2**. These drive units Uxy are connected to an external CPU (Central Processing Unit) **21** through a bus line **22**.

The external CPU **21** communicates with the drive units Uxy through the bus line **22** and controls the whole backlight **2**.

For example, light quantity data are acquired from all of the backlight units **10**, **10**, . . . which form the backlight **2**, and the brightness of each of the backlight units **10**, **10** is obtained. If the quantity of light of the backlight units **10**, **10**, . . . which form the backlight **2** deviates from a predetermined area, instructions (command or data) to adjust the quantity of light are sent to the drive unit Uxy.

Further, although not shown, for example, when a user performs a required operation for adjusting a brightness level of the display apparatus so as to change a brightness level of the whole backlight **2**, instructions (command and data) to change the brightness level to all the drive units Uxy are sent.

For example, the bus line **22** is a bus of the I^2C (Inter Integrated Circuit) standard and has a data bus, a command bus, and an address bus.

In this case, the external CPU **21** and respective drive units Uxy are connected by means of the bus line **22** in a daisy chain (single line connection), thus allowing communication between the external CPU **21** and each drive unit Uxy and communication between the drive units Uxy.

In the preferred embodiment, the drive unit Uxy is provided for each of the backlight units **10** and **10**. For example, starting with the drive unit Uxy in the upper left as shown in FIG. **10**, five sheets of them are arranged in the row direction (x direction) and five sequences of them are arranged in the column direction (y direction). In other words, in this case, as shown in FIG. **10**, a total of 25 drive units Uxy are provided, from a drive unit U**11** corresponding to the upper left backlight unit **10** (where, the light guide plate **13** is shown) to a drive unit U**55** corresponding to the lower right backlight unit **10**.

These drive units Uxy are connected in the order of, for example, drive units U**11**→U**12**→, . . . , U**15**→U**25**→U**24**→, . . . , U**21**→U**31**→, . . . , →U**54**→U**55** by means of the bus line **22**. The drive unit U**55** is connected with the external CPU **21**.

The above-mentioned drive units Uxy are arranged to control the backlight unit **10**, based on various commands transmitted from the external CPU **21** through the bus line **22**.

Thus, the external CPU **21** can choose an arbitrary drive unit Uxy on the bus line **22** according to an address signal which identifies each of the drive units Uxy and is transmitted over the bus line **22**. For example, it is also possible that the external CPU **21** may control operations of all the backlight units **10** and **10** simultaneously by way of simultaneous selection so as to have the whole backlight **2** turned off.

Further, since command communication between respective drive units Uxy can also be established in this case, it is possible to exchange various data among the drive units Uxy, for example.

In addition, in the preferred embodiment, although it is arranged that the whole backlight **2** is controlled by the external CPU **21**, it is also possible to arrange that any of the drive units Uxy provided in the backlight unit **10** of the backlight **2** may be a host CPU so as to control the whole backlight, for example.

FIG. **11** is an example of a block diagram of a drive unit U such as described above.

As shown in FIG. **11**, the drive unit U is constructed to have at least an MPU (Micro Processing Unit) **31**, a voltage control unit **32**, a light source drive unit **33**, a light quantity detector **34**, and an A/D converter **35**.

The MPU **31** controls the whole drive unit U, based on the various commands etc. which are transmitted through the bus line **22**.

For example, the light quantity data which are detected by the light quantity detector **34** and converted to digital data by means of the A/D converter **35** are transmitted to the external CPU **21**, and a quantity of light of the fluorescence tube which is the light source **15** is adjusted based on the light quantity data.

Further, a memory **36** is provided in the MPU **31**, so that it is possible to hold data etc. from the external CPU **21**. In addition, a drive voltage is supplied to the MPU **31** through a power supply line **23** disposed together with the bus line **22**.

The voltage control unit **32** controls a power supply voltage from the power supply line **23** to be a predetermined voltage level, which is outputted to the light source drive unit **33**. By controlling the voltage level supplied to the light source drive unit **33**, based on an offset data etc. held in the memory **36** of the MPU **31**, brightness unevenness is corrected on a per backlight unit basis.

In addition, a tube current control unit **37** as shown by broken lines may be provided between the light source **15** and the light source drive unit **33**, and a tube current which flows when driving the light source **15** may be controlled based on the offset data stored in the memory **36** of the MPU **31**, to thereby correct the brightness unevenness per unit backlight unit **10** which constitutes the backlight **2**. The tube current control unit **37** as mentioned above can easily be constituted by a variable resistor etc.

The light source drive unit **33** comprises an inverter etc., for example, converts a direct current voltage supplied from the voltage control unit **32** into an alternating current voltage so as to be supplied to the fluorescence tube which is the light source **15**.

Further, the light source drive unit **33** controls the quantity of light of the light source **15** to be a predetermined quantity of light (brightness) level according to a control signal supplied from the MPU **31**.

As a specific method of controlling a light quantity level in the light source drive unit **33** as mentioned above, a method of controlling the quantity of light by duty modulation can be envisaged depending on a type of the light source **15**, if the light source **15** is the fluorescence tube, for example.

By "method of controlling the quantity of light by duty modulation" we mean a method of controlling the quantity of light of the light source **15** from 100% to 0% (turned off continuously when a main drive frequency is approximately 70 kHz, and the high frequency is changed into a ratio in time of ON-OFF (duty) at 60 Hz intervals.

The light quantity detector **34** comprises a photo-coupler etc., converts a light quantity value of the light source **15** into a corresponding electric signal which is outputted to the A/D converter **35**.

The A/D converter **35** converts an analog output according to the light quantity value from the light quantity detector **34** into a digital data which is outputted to the MPU **31**.

Further, the drive unit U can suitably modify or add a light quantity detection means for detecting a change in quantity of light (brightness), according to a type of the light source **15**, a specification of the MPU **31**, etc.

For example, a temperature detector **38** as shown by broken lines may be provided as the light quantity detection means in addition to the above-mentioned light quantity detector **34** when the light source **15** is formed by the LED. In this case, a structure of the whole backlight drive apparatus is as shown in FIG. **14**, the light quantity detector **34** and the temperature detector **38** from each drive unit U are attached to the light source **15**.

In this case, temperature information detected by the above-mentioned temperature detector **38** is converted into a digital data by the A/D converter **39**, then supplied to the MPU **31**.

Then, based on this temperature data, the MPU **31** controls the drive voltage which is supplied from the light source drive unit **33** to the light source **15**.

The above-mentioned temperature detector **38** is effective when the light source **15** is constituted by the LED etc. whose brightness considerably changes as a temperature changes.

Thus, in the drive apparatus for the backlight of the preferred embodiment, the external CPU **21** which is a drive control unit performs drive control of the drive unit U provided for each of the backlight units **10** through the bus line **22**. In other words, individual control of the backlight unit **10** is performed by the drive unit U provided for each of the backlight units **10**, **10**, the whole control of the backlight **2** is performed by the external CPU **21**.

According to the structure as described above, the external CPU **21** may only control the drive of the drive unit U provided for each of the backlight units **10**, **10** so as to perform the drive control of the whole backlight **2**.

Further, since the drive unit U is provided in each of the backlight units **10**, **10**, . . . , the external CPU **21** can similarly perform the drive control even when the backlight units **10**, **10**, . . . are changed in size or the backlight units **10**, **10**, . . . are replaced, for example.

Moreover, in the preferred embodiment, the external CPU **21** acquires the light quantity data of all the backlight units **10**, **10**, . . . from the drive units U, and obtains variations in brightness of the backlight units **10**, **10**, . . . so as to correct the variations in brightness of the respective backlight units **10**, **10**, . . . , to thereby prevent brightness unevenness from occurring in the backlight **2** even when the backlight **2** is constructed by combining the plurality of backlight units **10**, **10**, ...

Still further, there is an advantage that by providing the drive unit U in each backlight unit **10**, the quantity of light of the light source **15** can be adjusted to a proper light quantity level in each drive unit U, based on the light quantity data detected by the detection means of the quantity of light of each of the drive units U.

Now, an example of a system for automatically correcting the brightness unevenness of the above-mentioned backlight **2** will be explained with reference to FIG. **12**A and FIG. **12**B.

In addition, it is assumed herein that an automatic correcting system is executed by the external CPU **21** at a predetermined timing, such as a timing when turning on a power supply etc.

For example, when the backlight **2** is formed by using the plurality of backlight units **10**, **10**, . . . , brightness unevenness also takes place in the whole backlight **2**, because each of the backlight units **10**, **10**, . . . has different brightness.

For example, it is assumed that the backlight **2** is constructed by using backlight units **10**, **10**, . . . of m.times.n (where m and n are natural numbers).

For example, according to the light quantity data detected in the light quantity detector **34** of the drive unit U (mn) when all the backlight units **10**, **10**, . . . are turned on at 100% of brightness, it is further assumed that a backlight unit of a certain drive unit U (ab) has the maximum brightness, and a backlight unit of a certain drive unit U (cd) has the minimum brightness among the drive units –U (mn) of the backlight units **10**, **10**, . . . , where $a \neq c$, $b \neq d$, $0 \leqq a$, $c \leqq m$, $0 \leqq b$, $d \leqq n$.

For example, when all the backlight units are turned on at 100% of brightness, it is assumed that maximum brightness is obtained in the backlight unit of the drive unit U (**11**), and the minimum brightness is obtained in the backlight unit of the drive unit U (**34**) as shown in FIG. **12**A. Then, in this case, the quantities of light of the drive units U (**11**) and (**53**) which are away from a range of a brightness difference Bd set up based on the level of the minimum brightness are caused to be within the range of the brightness difference Bd, so as to correct the brightness unevenness of the backlight **2** as shown in FIG. **12**B.

In addition, in this case, based on a level of the minimum brightness, the brightness difference Bd may be set within an arbitrary range, if it is within a limit in which the variations in brightness of the whole backlight **2** are not significant. For example, it is possible to set a range of the brightness difference Bd to "0", i.e., the brightnesses of all the backlight units **10**, **10**, . . . can be set to be equal. However, the highest brightness of the backlight **2** is always necessary to be in compliance with the minimum brightness level in the all backlight units **10**, **10**, . . . , which is somewhat disadvantageous in brightness.

Moreover, for example, when the brightness of the whole backlight **2** is caused to be 50% of the previous one according to a user's operation etc., if a command for changing the brightness and data about new brightness are transmitted from the external CPU **21** to the drive units U (mn) of all the backlight through the bus line **22**, it becomes possible to reduce the brightness of the whole backlight **2** to 50%, as shown in FIG. **13**.

FIG. **15** is a flow chart showing a process in which the external CPU **21** operates the drive unit U for realizing a drive operation by means of a backlight drive apparatus such as described above.

In this case, firstly in step S**101**, the external CPU **21** transmits a command for causing light sources **15**, **15**, . . . of the respective backlight units **10**, **10**, . . . to be turned on at 100% of brightness, to the drive unit U of the backlight units **10**, **10**, . . . which constitute the backlight **2**.

Next, in step S**102** the drive unit U of each of the backlight units **10**, **10**, . . . is requested to provide the light quantity data detected by the light quantity detector **34** so as to acquire the light quantity data from each of the backlight units **10**, **10**, ...

Then in the subsequent step S**103**, as shown in FIG. **12**A, a command for controlling the quantity of light is transmitted to the drive units U (**11**) and (**53**) of the backlights which are away from the range of the brightness difference Bd, out of the backlight units **10**, **10**, . . . , in order that the brightness difference unevenness of the backlight units **10**, **10**, . . . which form the backlight **2** may be inconspicuous. Thus, it becomes possible to correct the brightness unevenness of the whole backlight **2**.

3. Backlight of Second Preferred Embodiment

Next, the backlight of a second preferred embodiment will be described.

FIG. **16** and FIG. **17**A through FIG. **17**C are views showing a structure of the backlight of the second preferred embodiment.

As shown in these FIG. **16**, FIG. **17**A through FIG. **17**C, a backlight **40** of the second preferred embodiment forms the pair of units **10***a* by combining two backlight units **10**, **10** in the same direction. Then, as shown, the lamp accommodation sections **11***a* of these pairs of units **10***a* are brought into contact with one another so as to form the backlight **40**. In this case, therefore, the backlight **40** can be formed without arranging the pairs of units **10***a* in the alternate order.

A light source **41** as shown in FIG. **17**A through FIG. **17**C is accommodated in the lamp accommodation section **11***a* of the thus formed backlight **40**. In other words, in this case, a fluorescence tube which is sufficiently longer than the backlight unit **10** and longer than the lamp accommodation section **11***a* of the backlight **40** formed by combining the pair of units **10***a* is used as a light source **41**, for example. In other words, in this case, the backlight **40** is formed by combining two composite boards, considering the light guide plates of five backlight units **10**, **10**, . . . as one composite board.

The above-mentioned drive apparatus for driving the backlight **40** will be described. In addition, since a structure of the drive unit U in this case is the same as that of FIG. **11** as shown above, detailed explanation will not be repeated.

FIG. **18** are a rear view and a side view showing a structure of the above-mentioned backlight **40**.

As can be seen from these FIG. **18**, the fluorescence tube which is a light source **41** is formed over a plurality of the light guide plates **13** in the backlight **40**.

A structure of the backlight drive apparatus which drives the above-mentioned backlight **40** is as shown in FIG. **19**. That is, one drive unit Uxy (x: row, y: column) is formed for one light source **41**, and the bus line **22** is connected between the drive unit Uxy and the external CPU **21**. For example, these drive units Uxy are connected in the order of the drive units U**11**→U**21**→, . . . , →U**51**. The drive unit U**51** is connected with the external CPU **21** as illustrated.

Even when the backlight **40** is formed providing the light source **41** over the plurality of backlight units **10**, **10** in such a manner, the backlight **40** can be driven. Further, when it is constituted in such a manner, there is an advantage that fewer drive units U are needed, compared with a case where the backlight **2** of the above-mentioned first preferred embodiment is driven.

Further, in this case a length of the fluorescence tube which is the light source **41** is long, so that variations in the quantity of light arise as the fluorescence tube is degraded.

As shown in FIG. **20**, in this case, the number of the light quantity detectors **34** can be increased which detect the variations in the quantity of light of the fluorescence tube in the drive unit U, to thereby detect the variations in the fluorescence tube which is a light source **41**. In this way, since the brightness unevenness of the fluorescence tube itself which is the light source **41** is detectable, it becomes possible to provide function in which the external CPU **21** may know the time to replace the light source (fluorescence tube) **41**, based on the brightness data sent from the drive unit U etc., and may prompt a user to replace the fluorescence tube.

4. Backlight of Third Preferred Embodiment

Next, the backlight of a third preferred embodiment will be described.

FIG. **21**A, FIG. **21**B, and FIG. **22**A through FIG. **22**C are views showing a structures of the backlight of the third preferred embodiment.

As shown in these figures, similar to the above-mentioned backlight **40**, a backlight **50** of the third preferred embodiment forms the pair of units **10***a* having combined two backlight units **10** and **10** in the same direction. Then, two pairs of units **10***a*, **10***a* are arranged so as to bring the lamp accommodation sections **11***a* into contact with each other, to thereby form a pair of units **50***a* which include four backlight units **10**, **10**, . . . as shown in FIG. **21**A.

Similarly, a pair of units **50***b* in different directions by 180 degrees as shown in FIG. **21**B is formed by combining four backlight units **10**.

Considering these pairs of units **50***a* and **50***b* as one backlight unit, a fluorescence tube which substantially doubles the length of the backlight unit **10** is accommodated, as the light source **51**, in the lamp accommodation section **11***a* of these pairs of units **50***a* and **50***b* as shown in FIG. **22**A, so that the backlight **50** having a structure as shown in FIG. **22**B is formed. Further, the back view of the backlight **50** in this case is as shown in FIG. **22**C. That is, in this case, the light guide plates of four backlight units **10**, **10**, . . . are considered as one composite board, whereby the backlight **50** is formed by combining the composite boards.

Therefore, although not shown, as can be seen from the above description, the drive apparatus which drives the backlight **50** having such a structure can be constructed in such a manner that one drive unit Uxy (x: row, y: column) is provided for one light source **51** and the bus line **22** is connected between these drive units Uxy and the external CPU **21**.

Further, as a modification of the backlight **50** as described above for example, it is also envisaged that the backlight may be constructed by composing one that is provided with the comparatively long light source (fluorescence tube) **51**, considering the light guide plates of two backlight units **10**, **10** as one composite board, and one that is provided with the light source (fluorescence tube) **15** for each backlight unit **10**.

Then, the rear view and the side view of the backlight in that case are as shown in FIG. **23**.

Further, the structure of the backlight drive apparatus which drives such a backlight is as shown in FIG. **23** and FIG. **24**.

In this case, one drive unit Uxy (x: row, y: column) is provided for each of the light sources **51** and the light sources **15**. The bus line **22** is connected between these drive units Uxy and the external CPU **21**. In FIG. **24**, the drive units Uxy are connected in the order of the drive units U**1**→U**12**→U**13**→U**23**, . . . , →U**21**→U**31**→U**33**, . . . , →U**53**, so that the drive unit U**53** is connected with the external CPU **21**. In this way, even when the backlight is constructed by composing the light sources **51** and **15** which are different in length, the drive unit U can control them.

Further, another example of connection of the bus line **22** is shown in FIG. **25**.

In this case, the drive units Uxy are connected in the order of the drive unit U**11**→U**21**→, . . . , U**52**→U**53**→U**43**→U**42**.→, . . . , →U**13**, so that the drive unit U**13** is connected with the external CPU **21**. In this case, even when the backlight is constructed by composing the light sources **51** and **15** having different lengths, the drive unit U can control them.

In addition, the structure of the backlight of this preferred embodiment as described above is merely by way of example, the backlight in accordance with the present invention need only be formed in such a way that the backlight for illuminating, from the back, the liquid crystal panel which is constituted by at least a single panel is formed by the plurality of backlight units.

Further, the liquid crystal panel of the liquid crystal display apparatus of the present invention may be constructed by using one or a plurality of liquid crystal panels.

Moreover, although in the backlight unit of the preferred embodiment the light source unit **11** is disposed at the back of the light guide plate **13** by using the reflective prism, this is merely an example. Another structure of the backlight unit may be envisaged which is applicable to the backlight of the present invention.

For example, as shown in FIG. **26**A, it can be constructed by using a backlight unit **70** in which a light source unit **71** is disposed at a side of the wedge-shaped light guide plate **13**, or a backlight unit **72** in which the light source unit **71** are disposed at one side or both sides of a planar light guide plate **73** as shown in FIG. **26**B.

However, when the backlight is constructed by combining the backlight units **70** and **72** having the structure as shown in FIG. **26**A and FIG. **26**B, it is constructed by combining four sheets of the backlight units **70** and **72** in the directions as shown in FIG. **27**A, for example. Alternatively, after combining them as shown in FIG. **27**B, it can be realized only when a long fluorescence tube is commonly used as the fluorescence tube of the backlight **70** and **72** in the same direction.

As described above, with respect to the backlight of the present invention, the lighting side which illuminates the back of the video display unit formed by the single panel is formed by combining the plurality of backlight units in the planar shape, so that the backlight of the edge light system which can illuminate the video display unit of large area uniformly and more with high brightness can be realized.

Further, according to the present invention, it is not necessary to arrange a lot of fluorescence tubes on a side edge of one light guide plate, for example, in order to attain the backlight of high brightness, whereby, there is no need to thicken the acrylic resin which forms the light guide plate, and the weight saving of the backlight can be attained.

Therefore, when the liquid crystal display apparatus, for example, is formed by using the backlight of the present invention, a display apparatus which is unprecedentedly large-sized, reducing weight can be realized.

When the diffusion board is arranged in the position apart from the backlight and between the backlight and the video display units, brightness unevenness at a junction section of the backlight unit can be inconspicuous.

Further, in the drive apparatus for the backlight of the present invention, the backlight units which constitute the backlight are respectively driven by means of the drive units, and the drive control unit controls the backlight unit, to thereby control the whole backlight.

The invention claimed is:

1. A drive apparatus for a backlight formed by combining a plurality of backlight units and a plurality of light sources, said drive apparatus comprising:

a plurality of drive units, a respective drive unit being provided for a respective light source and configured to perform drive control of the respective light source, said plurality of backlight units being arrayed in a plurality of rows in a plane that extends behind and parallel to a video display unit formed by a single panel so as to illuminate a back of the video display unit, each of the plurality of light sources extending through at least one of the plurality of backlight units, the plurality of backlight units being arrayed in two directions so as to be arranged in the plurality of rows and a plurality of columns that extend behind and parallel to the video display unit formed by the single panel, backlight units in adjacent columns being oriented in different directions which differ from one another by 180 degrees, each backlight unit including a reflective prism, a light guide plate, and a condensing processed surface, each light source including protruding portions which protrude from opposite sides of a corresponding one of the backlight units, at least one of the protruding portions extending beneath a portion of an adjacent backlight unit in an adjacent column; and

a drive control unit configured to perform drive control of said drive units, said plurality of drive units and said drive control unit being connected in a daisy chain.

2. The drive apparatus for the backlight as described in claim **1**, wherein said drive unit comprises a light quantity detector configured to detect a light quantity of a light source of said respective backlight unit, and a light quantity control unit which controls the light quantity of said light source to a predetermined level based on a result of said detected light quantity of said light quantity detector.

3. The drive apparatus for the backlight as described in claim **2**, wherein a plurality of said light quantity detectors are provided.

4. The drive apparatus for the backlight as described in claim **2**, wherein said light quantity control unit is configured to control a light quantity of said light source to a predetermined level by varying a duty ratio of a drive voltage supplied to said light source based on the result of said detected light quantity of said light quantity detector.

5. The drive apparatus for the backlight as described in claim **1**, wherein said drive unit includes a temperature sensor configured to detect a temperature of said light source.

6. The drive apparatus for the backlight as described in claim **1**, wherein said drive control unit is configured to generate and transmit an offset data which offsets the light quantity at said drive units, based on a light quantity data transmitted from said plurality of drive units.

7. The drive apparatus for the backlight as described in claim **6**, wherein said drive unit variably controls voltage level of a light source drive voltage supplied to said light source so that the light quantity of said light source is set to a predetermined level, the predetermined level based on said offset data transmitted from said drive control unit.

8. The drive apparatus for the backlight as described in claim **6**, wherein said drive unit variably controls current flowing through said light source so that the light quantity of said light source is set to a predetermined level, the predetermined level based on said offset data transmitted from said drive control unit.

9. The drive apparatus for the backlight as described in claim **1**, wherein at least two backlight units share a single one of the plurality of light sources.

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